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STUDIES IN EXPERIMENTAL ALCOHOLISM

BY

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STUDIES IN EXPERIMENTAL ALCOHOLISM.

By Reid Hunt.

Chief of the Division of Pharmacology, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service.

I.

THE EFFECT OF ALCOHOLISM UPON RESISTANCE TO ACETONITRILE.

Summary.—In the following experiments it is shown that animals to which alcohol has been administered for some time acquire an increased susceptibility to a definite poison (acetonitrile); this occurs after the administration of amounts of alcohol far too small to ever cause indications of intoxication and from doses which almost certainly cause no anatomical lesions which could be detected by present methods. It is shown that this increased susceptibility is not due to a general "lowering of resistance" but is associated with a distinctly increased power of the body to break up the molecule of acetonitrile; reasons are given for believing that this increased breaking up of the acetonitrile depends upon increased powers of oxidation on the part of the body.

It is believed that these experiments afford clear experimental evidence for the view that extremely moderate amounts of alcohol may cause distinct changes in certain physiological functions and that these changes may, under certain circumstances, be injurious to the body. The results also afford further evidence that in some respects the action of alcohol as a food is different from that of carbohydrates, and finally that in all probability certain physiological processes in "moderate drinkers" are distinctly different from those in abstainers.

The effects upon man of the moderate use of alcohol have long interested pathologists and physiologists as well as clinicians. The earlier efforts to solve this problem were made by pathological anatomists. After the anatomical changes resulting from the excessive use of alcohol had been recognized, pathologists turned their attention to the effects of smaller amounts of alcohol; for this purpose many experiments were made upon the lower animals, for it seemed probable that in this way better material for study could be obtained than from human subjects. As Professor Welch[a] points out, these anatomical studies on experimental alcoholism have, however, been distinctly disappointing and throw but little light on functional disturbances.

[a] Physiological Aspects of the Liquor Problem, Vol. II.

This is true notwithstanding the fact that animals were given intoxicating doses daily for years. Thus the experiments on swine of Dujardin-Beaumetz and Audigé (1879–1884) extending over several years were practically negative. In Friedenwald's experiments, carried out in Welch's laboratory, rabbits were given intoxicating doses of alcohol for long periods—sometimes for years; the results were stated by Welch to be meager. Doctor Welch further states, "No systematic experiments have been made to determine the pathological effects on animals of the long-continued use of alcohol in quantities so small as to produce no manifest symptoms of intoxication; but in view of the comparatively meager results in the experiments with moderate intoxicating doses, it seems improbable that experiments of the former character would yield positive results," and, further, that from the clinical side, however, "instances have been reported in increasing numbers in recent years of the occurrence of diseases of the circulatory, renal, and nervous systems, reasonably or positively attributed to the use of alcoholic liquors in persons who regarded themselves, or were regarded by others, as moderate drinkers." In many cases the injury was latent, and only manifested itself as the result of some accident or of an acute febrile disease. The relation of alcoholic liquors to gouty manifestations has long been recognized, as well as the increased liability of alcoholics to contract certain diseases or to contract them in especially severe form. Much has also been written, from both the clinical and experimental side, on the relation of alcohol to infection; the results, which are, as yet, not very concordant have recently been summarized by Meltzer.[a] In most, if not all, of this experimental work the alcohol was given in intoxicating doses.

In a series of experiments to be described in this paper I have found profound modifications of certain physiological processes to result in a comparatively short time from doses of alcohol so small that indications of intoxication never occurred. So far as I am aware this is the first series of experiments in which distinct physiological changes have been found to result from what may be called the strictly moderate use of alcohol. Although there may be some doubt as to the exact explanation of the results I have obtained, any positive results in this field may prove of interest.

Before describing these experiments, however, a few words may be said upon the more general effects of alcohol upon the metabolism. The views upon this subject and especially upon the effect of alcohol upon physiological oxidations have undergone great changes in the

[a] Brit. Med. Journ., Nov. 24, 1906, p. 1463; see also Meltzer, Amer. Med., vol. 4, p. 60; 1902, and Trommsdorff, Arch. f. Hyg., vol. 59, p. 1; 1906.

last few years, but it may be safely said that the older views are still generally current in medical circles and medical literature. Thus, the belief was formerly quite general that alcohol has a specific action in retarding the metabolism of body material, both fat and proteid; alcohol in moderate quantities was said to "prevent waste" or "conserve the tissues." Thus, the obesity so often found in alcoholics was attributed to a direct interference with the oxidation of fats; the increased excretion of uric acid, observed after alcohol, was attributed to diminished oxidation—the view then being held that urea was normally formed from uric acid and that the processes of oxidation involved were retarded by alcohol. "Later as the functions of the nonnitrogenous nutrients of food came to be better understood and the fact established that alcohol is oxidized, as they (the nonnitrogenous nutrients) are, in the body, became fully established, the view has become common that its effect in retarding or protecting metabolism is to be explained by its action as food rather than as a drug—that, in other words, it tends, by its own oxidation, to prevent the oxidation of other materials." [a] According to these newer views the obesity is due to an excess of food; i. e., the food remains unoxidized not because the body is rendered incapable of oxidizing it, but because an excess of more easily oxidizable food is provided.[b] The argument of diminished oxidation based on the increased excretion of uric acid is still supported, but in a form very different from the original. As this is about the only specific instance [c] in which such an action is attributed to alcohol a few words may be devoted to it. A brief review of the current views on the formation of uric acid will make this supposed relation clear. Uric acid is believed to arise from the nucleic acids of either the food or the tissue (and from hypoxanthin, of unknown origin, of the muscle), that having the former origin being the "exogenous," that of the latter, the "endogenous," uric acid. A specific intracellular enzyme—nuclease—hydrolyzes nucleic acids with the production of purin bases and other substances; the guanin and adenin thus formed are transformed under the influence of other specific enzymes—guanase and adenase—into xanthin and hypoxanthin, respectively; hypoxanthin is converted, by means of an oxidase, into xanthin and this, by

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[a] Atwater, Physiological Aspects of the Liquor Problem, Vol. II.

[b] Bunge attributes the effect of alcohol in causing obesity to its effect upon the brain which makes the person indisposed to muscular exercise (Leheb. der physiol. v. 2, p. 538, 1905.

[c] The experiments of Simonowsky and Schoumoff (Pflüger's Archiv, v. 33, p. 251; 1883–84) on the inhibiting action of alcohol upon the oxidation in the body of benzol to phenol are often quoted; apparently, however, no conclusions can be drawn from them on account of the inexactness of the method used for determining the phenol.

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further oxidation, into uric acid.[a] Thus, one factor in the amount of uric acid excreted is the extent to which these changes of hydrolysis and oxidation occur. The other factor is the extent to which the uric acid so formed is further oxidized, for many organs have been shown to contain an oxidase capable of destroying uric acid. Alcohol administered with purin-containing foods increases the output of uric acid in the urine[b] and the accepted explanation of this is that this increased output occurs because the alcohol inhibits the oxidation of the uric acid. This explanation probably accords best with the facts at present known, especially if certain of the views of Burian and Schur in regard to the "integral factor" be accepted. Still there are so many unknown factors in nucleic acid metabolism[c] that another explanation of the effect of alcohol does not seem to be entirely impossible, namely, that alcohol increases the activity of the enzymes (hydrolytic or oxidizing, or both) by which the uric acid is formed;[d] or it might be supposed to accelerate the formation, in muscle, of hypoxanthin which is subsequently converted into uric acid. Further, on the explanation that alcohol inhibits the oxidation of uric acid, it is difficult to see why it should not inhibit that of endogenous origin also, for it is not believed that all of that formed is normally excreted.[e]

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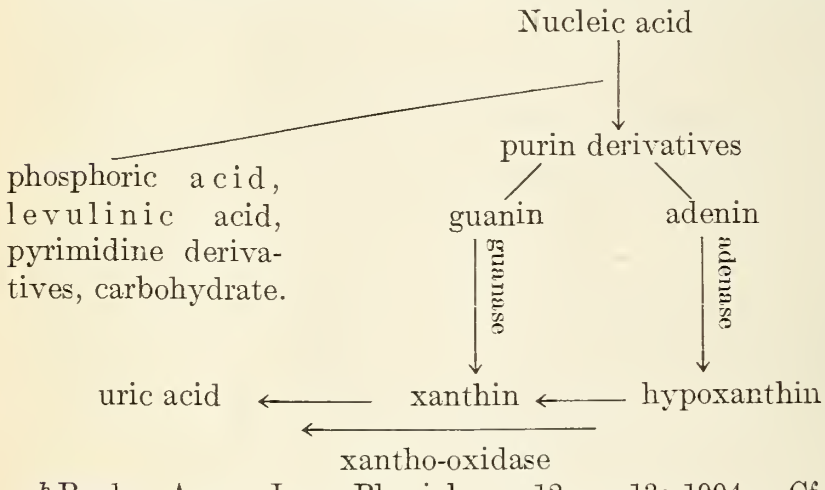
[a] These reactions are expressed by W. Jones in the following scheme:



[b] Beebe, Amer. Jour. Physiol., v. 12, p. 13; 1904. Cf. also Eschenburg (Münch. med. Woch., 1905, p. 2265), who obtained similar results with a patient suffering with gout; Rosenfeld, Einflüss des Alcohols auf den Organismus; Pringsheim, Zeit. für physikal. und diät. Therapie, v. 10, p. 284; 1906.

[c] Kossell and Steudel, for example, have suggested that certain pyrimidine bodies may be converted into uric acid.

[d] Burian (Hoppe-Seyler's Zeitschr., v. 43, p. 528; 1905) found tartronic, dialuric and salicylic acids to accelerate the conversion of purin bases into uric acid in extracts of the liver of the beef. Rockwood, at the December (1906) meeting of the American Chemical Society, reported experiments in which an increased output of endogenous uric acid was found to follow the administration of sodium salicylate.

[e] In any case the experiments quoted above are not conclusive as regards the effects of the habitual use of alcohol, for they were made upon those unaccustomed to the use of alcohol and were of but a few days' duration. In chronic alcoholism, Pollak (Dtsch. Arch. f. klin. Med., v. 88, p. 224; 1906) found a retention, or delayed excretion, of uric acid after the administration of nucleic acid.

In fact, both Rosenfeld and Pringsheim (who did not, however, take into consideration the difference in the effect of alcohol upon the endogenous and exogenous uric acid) attributed the increased excretion of uric acid, following the administration of alcohol, to an increased destruction of nucleic acid-containing proteids. In his striking way, Rosenfeld said that "alcohol hypocritically spared the ordinary proteids that it might rage all the more fiercely among the nucleoproteids without betraying itself in the nitrogen equilibrium."

This is mentioned simply to show that there seem to be no facts which necessarily point to alcohol, in small amounts, having an inhibiting effect upon physiological oxidations. In fact, as our knowledge concerning specific cases of oxidation in the body increases, it becomes more and more apparent that the commonly used expressions that a substance "accelerates" or "retards" physiological oxidation are far too general.

Thus there is more and more a tendency to discuss the effects of substances upon specific cases of oxidation, and I have been led to believe that alcohol probably causes increased oxidation in some cases. The substance with which I have chiefly experimented in this connection is acetonitrile. This substance may seem at first to have a purely theoretical interest, but from a long series of experiments with it I have been led to the conclusion that a thorough study of its conduct in the animal body may throw light upon a number of obscure processes of metabolism.[a] Chemically, acetonitrile (CH_3CN), or methyl cyanide, may be considered as hydrocyanic acid in which the hydrogen atom has been replaced by the methyl group. Both chemically and physiologically, however, acetonitrile is very different from hydrocyanic acid, although it is almost certain that its physiological action is due to the slow liberation of hydrocyanic acid in the body.

So far as I am aware acetonitrile has never been found in nature, although it has long been supposed that analogous compounds occur in living protoplasm, and importance has been attributed to them in certain disorders of metabolism.

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[a] The thyroid, for example, is quite generally supposed to have the power of effecting the neutralization of certain poisons of metabolic origin. These poisons are, however, purely hypothetical, and the only known poison toward which the thyroid has been shown to have an antidotal action is acetonitrile. In a previous paper (Journ. Biolog. Chem., vol. 1, p. 33; 1905) I have shown that animals to which small doses of thyroid have been administered for a short time will survive the injection of several times the fatal dose of acetonitrile. The explanation of this action is not known; if it were it would almost certainly throw much light on the physiology of the thyroid. It may also be noted in this connection that the feeding of parathyroids does not have such an effect; on the contrary, it slightly increases the susceptibility to acetonitrile. This affords another illustration of the fact that the thyroid and parathyroids have, in some respects at least, very different physiological effects.

Chemically the nitriles are chiefly characterized by their ability to unite with water, with the formation of corresponding organic acids and ammonia. In fact, this is one of the most usual methods of preparing many organic acids in the laboratory. Acetonitrile, for example, reacts with water in the presence of an alkali or acid, forming acetic acid and ammonia:

$$CH_3CN + 2H_2O = CH_3COOH + NH_3.$$

Giacosa, one of the earliest experimenters on this subject, thought that a similar reaction occurred in the animal body. He based this belief upon the fact that the urine of animals, poisoned with acetonitrile, gives a red color with ferric chloride. It was soon found, however, that the substance giving this color was not acetic acid, but sulphocyanic acid—HCNS.[a] It was also found that hydrocyanic acid, when administered to animals, reappeared in part in the urine as sulphocyanic acid. This observation led to the interesting experiments on the antidotal action of certain sulphur compounds toward hydrocyanic acid, and to the suggestion of a form of treatment of hydrocyanic acid poisoning, which would probably be the best yet proposed, if it could be given promptly enough.

The discovery of sulphocyanic acid in the urine after the administration of acetonitrile (and some other nitriles) was the beginning of our real pharmacological knowledge of acetonitrile. It showed that the changes undergone by this substance in the body are, in some respects at least, entirely different from those which take place in the test tube; *in vitro*, acetic acid is formed; in the organism hydrocyanic acid is produced, and this subsequently unites with sulphur to form sulphocyanic acid. The poisonous effects of acetonitrile are thus attributed to the slow formation of hydrocyanic acid. The methyl group of acetonitrile appears in the urine as formic acid. The process by which hydrocyanic acid is formed from acetonitrile does not seem to have been discussed by former writers. The most natural supposition would be that there is a simple hydrolysis of the acetoni-

[a] The literature on the pharmacology of aceto- and other nitriles can be found by consulting the following:

Pelikan, Beiträge zur gericht. Med., Toxikol. und Pharmacodynamik, Würzburg, 1858, p. 93.

Giacosa, Zeitschr. f. physiol. Chem., v. 8, p.110; 1883–1884.

Lang, Arch. exp. Path. und Pharmakol., v. 34, p. 247; 1894.

Heymans und Masoin, Arch. int. de Pharmacodynamie, v. 3, pp. 77, 359; v. 7, p. 297; v. 8, p. 1; Journ. of Physiol., v. 23, suppl. p. 23.

Verbrugge, Arch. int. de Pharmacodynamie, v. 5, p. 161; 1899.

Meurice, ibid., v. 7, p. 11; 1900.

Fiquet, ibid., v. 7, p. 307; 1900.

Hunt, ibid., v. 12, p. 447; 1904; Journal of Biolog. Chem., v. 1, p. 33, 1905.

Brissemort, C. R. Soc. Biol., v. 60, p. 54; 1906.

trile with the formation of methyl alcohol on the one hand and hydrocyanic acid on the other, according to the equation

$$CH_3CN + H_2O = CH_3OH + HCN.$$

Such a reaction has not been obtained by chemical processes outside of the body, and we have no reason to suppose that it can occur within the body.[a] A study of a number of related nitriles led me to form another conception of the process by which the hydrocyanic acid is formed. On comparing the toxicity of a number of nitriles I noticed that there is a relation between the degree of toxicity and the ease with which the hydrocarbon residue, to which the cyanogen group is united, is oxidized in the body. Thus acetonitrile is the least poisonous of the series of aliphatic nitriles studied; the methyl group is the most difficult of the hydrocarbon residues in these compounds for the body to oxidize. Proprionitrile (C_2H_5CN) is many times more poisonous than acetonitrile; the ethyl group (C_2H_5) is readily oxidized in the body. After the administration of acetonitrile, formic acid (a product of the oxidation of the methyl group) is found in the urine; this shows that the oxidation is incomplete; after proprionitrile, the urine contains no formic (or acetic) acid, the ethyl group having been completely oxidized. The difference in the ease of oxidation of the methyl and ethyl groups is most strikingly illustrated by the fate in the body of ethyl and methyl alcohol, respectively. Ethyl alcohol, even when administered in comparatively large doses to man or other animals, is completely oxidized within a few hours; methyl alcohol, on the other hand, even in small amounts, is imperfectly oxidized, and the process extends over days instead of hours—a fact which led pharmacologists[b] to utter a word of warning concerning the use of methyl as a substitute for ethyl alcohol years before there was a single well-known case of poisoning by it in man, a warning recently justified by the hundreds of cases of death and blindness caused by this substance.[c]

Having formed the conception that hydrocyanic acid is liberated from acetonitrile through the oxidation of the methyl group,[d] I began experiments to determine the effects upon the toxicity of the nitrile,

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[a] The formation of hydrocyanic acid from nitroprussiate of soda, on the other hand, is probably the result of a hydrolytic cleavage (Carquet, Thèse, Montpelier, 1903).

[b] See Hunt, Johns Hopkins Hospital Bulletin, XIII, p. 213; 1902.

[c] See Buller and Wood, Jour. Amer. Med. Assoc., Oct., 1904.

[d] An analogy to this supposed mode of decomposition is that of ammonium chloride in rabbits. Pohl and Münzer (Arch. f. exp. Path. u. Pharm., v. 43, p. 28) found that when this substance was administered to rabbits the ammonia was converted into urea while the hydrochloric acid was liberated and the animals died of acid intoxication; the fatal dose of the ammonium chloride corresponded closely to the equivalent amount of hydrochloric acid. In a similar manner Kohn and Czapek (Hofmeister's Beit., v. 8, p. 302; 1906) explain the injurious effects of certain salts upon the growth of fungi. Some fungi use up the kations and the organisms become poisoned by the acids formed from the anions; others use up the anions and become poisoned by the alkalies formed from the kations.

of various agents currently supposed to influence physiological oxidations. One of the first substances studied in this connection was alcohol. Although familiar with the view that alcohol diminishes oxidation, I was led to the hypothesis that oxidation in this case would be increased. This reasoning was based on a consideration of the probable cause of tolerance for alcohol. It is rather striking that so little attention has been paid to this factor in alcoholism. Although tolerance is one of the most familiar facts in connection with alcohol, I could find no reference to it in a bibliography on alcohol covering several hundred pages. One of the few drugs studied from the standpoint of tolerance is morphine. Faust [a] found that the establishment of tolerance for morphine was accompanied by an increased power on the part of the organism to destroy (oxidize) morphine, and he attributed the tolerance to this power.[b] It seemed reasonable to suppose that the tolerance for alcohol is accompanied by a similar increased power on the part of the body to oxidize alcohol and it was but a further step to suppose that, if the body became increasingly capable of oxidizing alcohol, it would also oxidize alkyl groups in general, such as the methyl group, more readily. If this should occur with the methyl group of acetonitrile, then animals accustomed to alcohol should be especially susceptible to this nitrile. Such was found to be the case. Animals which had received for a few weeks or months small amounts of alcohol—amounts far too small to ever cause any indications of intoxication—succumbed to doses of acetonitrile which produced no symptoms in the controls which had received no alcohol. These seem to be the first experiments in which marked functional disturbances have been found in animals which may be compared to strictly moderate drinkers. The first series of these experiments were performed upon mice.

EXPERIMENTS ON MICE.

As was pointed out in a recent paper[c] the susceptibility of mice to acetonitrile varies very considerably; the age of the animal, the character of the food, the temperature and season, all seem to have an influence. Hence in order to obtain satisfactory results it is necessary to have many controls. In the following experiments great care was taken to keep the conditions as uniform as possible, and a number of controls were made in every experiment.

The alcohol was administered by soaking the food (usually oats) in it. There was probably some loss by evaporation; but this was lessened by having the feeding cups narrow and deep. The strength of

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[a] Arch. f. exper. Path. u. Pharmakol., v. 44, p. 216; 1900.

[b] Hausmann (Pflüger's Archiv., 113, p. 337; 1906) has recently suggested that possibly the form in which the morphine is excreted changes as the tolerance is established, so that the drug can no longer be detected by the usual methods.

[c] Hunt, Journ. Biol. Chem., vol. 1, p. 33; 1905.

the alcohol was slowly increased from 5 or 10 per cent to 40 or 50 per cent. By carefully observing the weight of the mice and not increasing the strength of the alcohol too rapidly, it was possible to keep the animals for months on this diet without any material loss of weight. The acetonitrile was injected subcutaneously in aqueous solution.

White mouse.—Food consisted of oats covered with alcohol; the strength of the alcohol was gradually increased.

Date.	Weight of mouse.	Remarks.
	Grams.	
July 22, 1904	17	5 per cent alcohol.
July 31, 1904	....	10 per cent alcohol
August 6, 1904	....	15 per cent alcohol.
August 12, 1904	16.6	20 per cent alcohol.
August 19, 1904	16.7	25 per cent alcohol.
August 24, 1904	....	30 per cent alcohol.
September 1, 1904	16.61	35 per cent alcohol.
November 3, 1904	17.36	3.99 milligrams acetonitrile (=0.23 milligram per gram) injected subcutaneously. Died in 2 hours.

Another mouse in this series died from 0.22 milligram per gram body weight; while another recovered from 0.18 milligram per gram. With a fourth one the alcohol was increased to 45 per cent; on December 24 it died from 0.25 milligram per gram. The weight of this mouse had increased during the alcohol period from 12 to 17.05 grams.

Control experiments to the above gave the following results: In one experiment the weight of the mouse had increased from 18.4 to 19.55 grams; it recovered from 0.36 milligram acetonitrile per gram. Another mouse, the weight of which had decreased from 18.05 to 17.72 grams, recovered from 0.38 milligram acetonitrile per gram body weight. A third one recovered from 0.39, a fourth one from 0.42, while a fifth one died from 0.4 milligram per gram.

Thus in this series the mice which had received alcohol died from about one-half the amount of acetonitrile as did those which had not received alcohol.

In another series the alcohol was increased more rapidly; the mice decreased a little in weight. Thus, for example:

Date.	Weight of mouse.	Remarks.
	Grams.	
May 17, 1904	21.51	20 per cent alcohol.
May 23, 1904	19.54	
June 27, 1904	20.15	
June 28, 1904	....	30 per cent alcohol.
July 5, 1904	18.38	
July 6, 1904	....	3.68 milligrams acetonitrile (=0.2 milligram per gram body weight). Died in 1 hour.

Other mice of this series died from 0.22 and 0.24, while one recovered from 0.18 milligram per gram body weight.

Control mice, namely, those which had been kept on water and oats, recovered from 0.4, 0.45, 0.5, milligram per gram, but one died from 0.55 milligram. Thus the alcohol mice succumbed to one-half to one-third the dose necessary to kill the controls.

Similar results were obtained in a number of other such experiments upon both white and gray mice. In no case did the mice show any symptoms of intoxication or any ill effects at all from the alcohol. There were only insignificant changes in weight, no greater than those in the controls, and the changes which did occur were as often in the direction of an increase as of a decrease.

The following experiments show in a striking manner how the susceptibility of mice may be increased by the feeding of alcohol. In the first experiment the mouse had been kept for four months in a small jar on a diet of oats soaked in water; its weight had remained practically unchanged throughout this period. At the end of this period acetonitrile, 0.5 milligram per gram body weight, was injected. The mouse recovered. It was then placed upon oats soaked in alcohol, the per cent of which was gradually increased to 45 per cent. After a little more than a month of this diet, 0.2 milligram acetonitrile per gram body weight proved fatal. The weight of the mouse had remained practically constant throughout this period. Control mice, which had received oats in water, recovered from 0.4 and 0.5 milligram per gram.[a]

In other experiments of this series, mice which had recovered from 0.4 and 0.5 milligram acetonitrile died, after six weeks of alcohol (during which they had maintained their body weight and had remained very active), from 0.23 and 0.27 milligram acetonitrile per gram body weight.

In another series mice which had been closely confined and kept on an oats diet for several months, and which had acquired a marked resistance to the poison, recovered from 0.7 to 0.8 milligram per gram; one after six weeks of the alcohol diet died from 0.4 milligram per gram, whereas the control (which had been kept on water) recovered from 0.8 milligram.

In other experiments of this character, in which similar results were obtained, the mice had lost some weight on the alcohol diet, and it was thought that this might have been a factor in their increased susceptibility. It will be shown below, however, that it is possible to reduce the weight of mice very considerably without causing any such increased susceptibility. In the following experiment the loss of weight was accompanied by a very marked increased resistance to the poison. In these experiments the mice were fed for some time upon a very

[a] It is very probable that these amounts were considerably less than the fatal dose, for it was found that mice kept in a small jar where they could obtain but little exercise, and on a diet of oats, became very tolerant for acetonitrile. This point will be referred to again.

limited amount of oats; there was a decrease in the body weight but a strikingly increased resistance to acetonitrile.

The following experiments will serve to illustrate these points:

Date.	Weight of mouse.	Remarks.
	Grams.	
January 18, 1905	18.21	Limited food begun.
January 24, 1905	17.01	
January 30, 1905	15.92	
February 6, 1905	16.42	
February 13, 1905	12.61	
February 15, 1905	14.11	On this morning the mouse was given full food, 16.93 milligrams acetonitrile (=1.2 milligrams per gram body weight). Survived.
February 16, 1905	....	Alcohol, 5 per cent on oats.
February 21, 1905	....	Alcohol increased to 10 per cent.
February 24, 1905	14.02	
February 27, 1905	....	Alcohol increased to 20 per cent.
March 3, 1905	13.61	
March 10, 1905	14.10	Alcohol increased to 25 per cent.
March 18, 1905	14.05	
March 22, 1905	....	Alcohol increased to 35 per cent.
March 29, 1905	14.25	Alcohol increased to 45 per cent.
April 5, 1905	15.32	
April 11, 1905	....	Alcohol increased to 60 per cent.
April 14, 1905	14.85	4.46 milligrams acetonitrile (=0.3 milligrams per gram body weight). Died.

The following control experiments were made: (a) (To the first injection) other mice of the same lot, which had been allowed to eat all that they would, succumbed to 0.6 and 0.65 milligram per gram body weight, while others of the series, which had been kept on the reduced diet, survived 0.9 and 1 milligram acetonitrile per gram body weight; (b) (to the second injection) mice, which had been kept on oats and water for the same length of time that the others had received alcohol, survived 0.65 and 0.6 milligram per gram. Other experiments of this series are as follows:

Date.	Weight of mouse.	Remarks.
	Grams.	
February 16, 1905	23.16	Limited food begun.
February 21, 1905	18.85	
February 27, 1905	18.25	20.08 milligrams acetonitrile (=1.1 milligrams per gram body weight). Survived.
March 1, 1905	....	Alcohol, 5 per cent on oats.
March 6, 1905	18.95	
March 7, 1905	....	Alcohol increased to 10 per cent.
March 12, 1905	....	Alcohol increased to 20 per cent.
March 14, 1905	19.61	
March 16, 1905	....	Alcohol increased to 25 per cent.
March 21, 1905	19.26	Alcohol increased to 35 per cent.
March 29, 1905	18.92	Alcohol increased to 45 per cent.
April 5, 1905	19.05	
April 7, 1905	19.02	5.71 milligrams acetonitrile (=0.3 milligrams per gram). Died in 2 hours.

Controls (a) (that is, mice which had received full food as long as the above one had received limited food) died from 0.65 and 0.6 milligram per gram mouse; controls (b) (that is, mice which had received oats and water as long as the above had received oats and alcohol) survived 0.6 and 0.55 milligram.

Another striking experiment of this character is the following:

Date.	Weight of mouse.	Remarks.
	Grams.	
February 16, 1905	18.15	Limited food begun.
February 21, 1905	15.25	
February 28, 1905	13.57	27.14 milligrams acetonitrile (=2 milligrams per gram). Survived.
March 3, 1905	....	5 per cent alcohol on food.
March 7, 1905	15.52	
March 8, 1905	....	Alcohol increased to 10 per cent.
March 12, 1905	....	Alcohol increased to 20 per cent.
March 14, 1905	17.85	
March 16, 1905	....	Alcohol increased to 25 per cent.
March 21, 1905	18.27	Alcohol increased to 35 per cent.
March 29, 1905	18.80	Alcohol increased to 45 per cent.
April 5, 1905	19.35	
April 6, 1905	19.31	6.76 milligrams acetonitrile (=0.35 milligrams per gram). Died in 18 hours.

Thus this mouse, when receiving a limited amount of food, recovered from four times the absolute amount of nitrile which caused death after it had been given alcohol; it recovered from nearly six times the relative dose (that is, in proportion to body weight).

Two control experiments of this series are given in detail, for in them the mice, although receiving all the food they would eat, also lost some weight but did not show an increased resistance to the nitrile.

Date.	Weight of mouse.	Remarks.
	Grams.	
February 16, 1905	24.82	Full feed.
February 24, 1905	21.52	
February 27, 1905	21.57	14.02 milligrams acetonitrile (=0.65 milligrams per gram). Died in 4½ hours.

The mouse in the experiment described immediately before this one had recovered from 27.14 milligrams, or from nearly double the absolute amount which was fatal in this case; the relative figures (that is, in proportion to body weight) were 3 to 1.

In the following control a nonfatal dose of nitrile was given and then the usual diet (oats and water) continued.

Date.	Weight of mouse.	Remarks.
	Grams.	
February 16, 1905	20.46	Full food (oats and water).
February 24, 1905	18.12	
February 27, 1905	17.45	8.73 milligrams acetonitrile (0.5 milligrams per gram). Survived.
February 28, 1905	....	Oats and water continued.
March 6, 1905	17.35	
March 14, 1905	17.82	
March 21, 1905	17.22	
March 29, 1905	17.75	
April 5, 1905	18.15	
April 7, 1905	17.82	12.98 milligrams acetonitrile (0.65 milligram per gram). Survived.

On comparing the second injection of the nitrile with that of the nitrile in the mouse on alcohol given above, p. 16, it will be seen that this mouse (on oats and water) recovered from 12.98 milligrams, whereas the mouse on alcohol died from 6.76 milligrams—the relative doses were 0.65 milligram and 0.35 milligram per gram body-weight. This experiment also illustrates what was invariably observed, namely, that one dose of nitrile did not render the mouse more susceptible to a second dose, and that a prolonged diet of oats and water tends to increase the resistance of mice to the poison. This experiment (and it is but one of many) also shows that the increased susceptibility of the alcohol mice which had received a previous injection of the nitrile can not be attributed to the latter.

In order to determine if poisons other than alcohol can, by "lowering the resistance," cause a similar increase in the susceptibility to acetonitrile, the following experiments were made:

Amyl alcohol.[a]—The oats, which formed the exclusive food of the mice, were covered with a solution, or emulsion, of amyl alcohol (Kahlbaum).

Date.	Weight of mouse.	Remarks.
	Grams.	
July 11, 1904	13.02	Amyl alcohol, 12 per cent.
July 18, 1904	12.05	
July 25, 1904	12.01	
August 5, 1904	10.70	
August 11, 1904	10.30	
August 15, 1904	10.96	3.84 milligrams acetonitrile (0.35 milligram per gram). Survived.

[a] This alcohol is not oxidized to any considerable extent in the body; the tolerance for it is probably not dependent upon oxidation processes; hence it seemed an especially favorable drug to compare with ethyl alcohol.

(Mice which had received ethyl alcohol up to 45 per cent for a similar period died from 0.2 and 0.23 milligram per gram.)

The mouse in the above experiment was placed upon oats soaked in ethyl alcohol.

Date.	Weight of mouse.	Remarks.
	Grams.	
August 17, 1904	....	Ethyl alcohol, 5 per cent.
August 19, 1904	11.25	Alcohol increased to 15 per cent.
August 25, 1904	....	Alcohol increased to 25 per cent
August 26, 1904	9.41	
August 31, 1904	9.85	
September 14, 1904	10.40	
September 21, 1904	11.43	
September 28, 1904	11.30	
October 5, 1904	11.86	
October 12, 1904	11.50	
October 20, 1904	12.80	
October 28, 1904	12.77	Alcohol increased to 35 per cent.
November 4, 1904	14.53	2.91 milligrams acetonitrile (0.2 milligram per gram). Died in 9 hours.

In the following experiment the strength of the amyl alcohol was increased gradually:

Date.	Weight of mouse.	Remarks.
	Grams.	
May 23, 1904	23.07	Amyl alcohol, 2 per cent.
May 25, 1904	....	Amyl alcohol increased to 4 per cent.
May 28, 1904	....	Amyl alcohol increased to 6 per cent.
May 31, 1904	23.80	
June 4, 1904	....	Amyl alcohol increased to 8 per cent.
June 6, 1904	23.63	
June 10, 1904	....	Amyl alcohol increased to 10 per cent.
June 13, 1904	22.58	
June 20, 1904	22.05	
June 21, 1904	....	Amyl alcohol increased to 12 per cent.
June 27, 1904	21.05	
July 5, 1904	20.98	
July 7, 1904	20.98	11.64 milligram acetonitrile (0.55 milligram per gram.) Survived.

Control mice which had been given ethyl alcohol died from 0.35 and 0.3 milligrams acetonitrile per gram.

Hydrated chloral.—Experiments similar to the above were performed with hydrated chloral. Although this drug frequently caused a considerable loss of weight, no increased susceptibility to acetonitrile was observed—thus:

Date.	Weight of mouse.	Remarks.
	Grams.	
January 9, 1905	17.92	Oats soaked in a 5 per cent solution of hydrated chloral.
January 13, 1905	15.45	
January 16, 1905	14.13	
January 22, 1905	13.71	4.1 milligrams acetonitrile (0.3 milligram per gram). Survived.
July 18, 1904	24.38	Oats in 5 per cent solution of hydrated chloral.
July 26, 1904	22.41	
August 5, 1904	20.62	
August 9, 1904	20.96	6.29 milligrams acetonitrile (0.3 milligram per gram). Survived.

(Control mice on alcohol, increased up to 45 per cent, died from 0.22 milligram per gram.)

The latter mouse was now placed upon ethyl alcohol:

Date.	Weight of mouse.	Remarks.
	Grams.	
August 10, 1904	....	5 per cent alcohol in oats.
August 15, 1904	21.11	Alcohol increased to 15 per cent.
August 25, 1904	....	Alcohol increased to 25 per cent.
August 26, 1904	20.70	
August 31, 1904	20.92	Alcohol increased to 35 per cent.
September 14, 1904	18.05	
October 20, 1904	19.20	
November 2, 1904	19.56	4.3 milligrams acetonitrile (0.22 milligram per gram). Died in 3 hours 50 minutes.

In the following experiments the difference between the effect of alcohol and hydrated chloral is still more marked.

Date.	Weight of mouse.	Remarks.
	Grams.	
May 31, 1904	19.82	Oats in 25 per cent alcohol.
June 6, 1904	19.72	
June 13, 1904	18.32	
June 20, 1904	19.55	
June 27, 1904	18.54	
July 5, 1904	19.71	
July 7 1904	19.71	2.95 milligrams acetonitrile (0.15 milligram per gram). Died in 3 hours.

Another mouse of the same lot was placed upon oats soaked in a 5 per cent solution of hydrated chloral.

Date.	Weight of mouse.	Remarks.
	Grams.	
May 31, 1904	16.38	Oats in 5 per cent hydrated chloral.
June 6, 1904	15.56	
June 13, 1904	15.37	
June 20, 1904	14.60	
June 27, 1904	13.73	
July 5, 1904	13.50	
July 6, 1904	13.50	4.73 milligrams acetonitrile (0.35 milligram per gram). Survived.

Another mouse of this series whose weight on the chloral diet had decreased from 26.6 to 19.27 grams also survived the injection of 0.35 milligram per gram.

Methyl alcohol.—A few experiments were performed in which the food was soaked in methyl alcohol. This alcohol, when continued for a short time, proved to be far more poisonous to mice than did ethyl alcohol, as has been shown to be the case for other animals;[a] no distinct increased susceptibility for acetonitrile was, however, noted.

Hydrochloric acid, etc.—A number of experiments were performed in which the food of the mice was soaked in 0.1 to 0.5 per cent hydrochloric acid. There was usually a marked loss of weight but no increased susceptibility to acetonitrile; on the contrary the resistance seemed to be increased. The feeding of potassium iodide, in doses sufficient to cause a marked loss of weight, increased, rather than decreased, the resistance to acetonitrile. A very large number of other substances (such as chloroform water, saccharine, sulphonal, thymol, tobacco, sodium benzoate and salicylate) were tried, but with negative results; only certain proteid substances gave results similar to alcohol.

Experiments with other cyanogen compounds.—A number of experiments were performed in which hydrocyanic acid and nitroprussiate of soda, sodium sulphocyanate, etc., were injected into mice which had been given alcohol for some time, the object being to see if the alcohol had caused a general "lowering of resistance" which would cause them to succumb to a smaller dose than the one fatal to normal mice. The results were negative; the alcohol mice were not more susceptible to these poisons than were the normal ones. The following experiments with nitroprussiate of soda illustrate this point:

Date.	Weight of mouse.	Remarks.
	Grams.	
July 25, 1904	14.98	5 per cent alcohol on oats.
July 31, 1904		Alcohol increased to 10 per cent.
August 6, 1904		Alcohol increased to 15 per cent.
August 8, 1904	14.51	
August 13, 1904		Alcohol increased to 20 per cent.
August 15, 1904	15.22	
August 16, 1904		Alcohol increased to 25 per cent.
August 19, 1904	15.70	
August 24, 1904		Alcohol increased to 30 per cent.
August 31, 1904	16.40	
September 1, 1904		Alcohol increased to 35 per cent.
October 5, 1904	15.95	
November 3, 1904	16.77	0.168 milligram nitroprussiate of soda (0.01 milligram per gram). Survived.

[a] See Hunt: The toxicity of methyl alcohol, The Johns Hopkins Hospital Bulletin, p. 213; 1902.

Another mouse of this series also recovered from 0.01 milligram per gram body weight of nitroprussiate of soda. Of the control mice which had received oats soaked in water, one died from 0.015 milligram of nitroprussiate of soda, another from 0.01, while a third recovered from 0.008 milligram per gram. Mice which had received the same amount of alcohol for the same period showed an increased susceptibility to acetonitrile.

Results similar to the above were obtained with hydrocyanic acid, sodium sulphocyanate, and guanidin carbonate.

The above results show that mice to which alcohol has been administered for some time are distinctly more susceptible to acetonitrile than are those which have received no alcohol; also that there is apparently something special about the poisonous action of alcohol, for certain other poisons which cause a loss of weight and so might be considered as agents which would probably "lower the general resistance" do not have this effect, and finally that the increased susceptibility which the alcohol mice show toward acetonitrile seems to be a special case for such mice as do not show an increased susceptibility toward other poisons related to acetonitrile (hydrocyanic acid, nitroprussiate of soda, and sodium sulphocyanate).

It was pointed out above (p. 10) that the formation of sulphocyanate from acetonitrile seemed to be a protective reaction on the part of the organism, the sulphocyanate being less poisonous than the hydrocyanic acid formed from the nitrile. Hence it might be supposed that the increased susceptibility of the alcohol mice to acetonitrile is due to a diminution of the power of the body to convert the liberated hydrocyanic acid into the sulphocyanate; in this case there should be a smaller excretion of sulphocyanate after nitrile in the animals on alcohol than in the normal. On the other hand, the hypothesis which led to these experiments was that as the body, as the result of the repeated administration of alcohol, acquired the power of oxidizing more and more of the hydrocarbon residues of alcohol, it also acquired the power of oxidizing more and more of the methyl group of the nitrile, by which process more and more of the cyanogen would be set free. The cyanogen thus formed might or might not combine with sulphur to form sulphocyanate. If the former occurred, the lack of an increased excretion of sulphocyanate in the urine would not necessarily mean that there had not been increased decomposition of the nitrile. On the other hand, if the alcohol animal excreted an increased amount of sulphocyanate, this would be strong evidence that there had been increased destruction of the nitrile with an increased formation of cyanogen and the increased toxicity could thus be explained.

In order to test the above hypotheses, determinations of the sulphocyanate in the urine were made after the administration of acetonitrile

to both normal and alcoholic animals. These experiments were performed for the most part upon guinea pigs for reasons given below.[a]

Methods.—In the earlier experiments, the sulphocyanate was extracted from the acidified urine with ether and determined, approximately, colorimetrically; later it was extracted with ether and determined volumetrically. Neither method gave satisfactory results, so that in subsequent experiments Lang's volumetric method was employed—titrating the urine with silver nitrate (this gives chlorine and sulphocyanate) and deducting from this the chlorine, determined by incinerating another portion of the urine with sodium carbonate and potassium nitrate. This method gave entirely satisfactory results with the urine of guinea pigs and usually with that of dogs. There seemed to be nothing present in the guinea pigs' urine which was precipitated by the silver nitrate except the chlorine and sulphocyanate. The method was not as a rule satisfactory in the case of the urine of the cat or rabbit, as the urine of these animals usually contained substances which, like chlorine and sulphocyanate, are precipitated by silver nitrate; the same was found to be the case with a few dogs.

EXPERIMENTS ON GUINEA PIGS.

Attention was called above to the variations in the susceptibility of normal mice to acetonitrile; some of the conditions influencing this are the age of the animals, the character of the food, the season, etc. All of these factors seem to be equally important in the case of the guinea pig; they also seem to influence the amount of acetonitrile which is converted into sulphocyanate. The per cent of acetonitrile which is converted into sulphocyanate seems also in part to depend upon the dose.

In the following experiments, care was taken to keep the conditions uniform; guinea pigs of the same age and weight were selected and they were then kept under identical conditions, except that to the food of some alcohol instead of water was added. The experiments were performed upon the same day, and in all cases duplicate analyses were made. The urine was collected and analyzed as long as it gave a decided reaction for sulphocyanate. The urine of the guinea pig, both of the normal and of those receiving alcohol, was found to be practically free of sulphocyanate; in some cases a faint qualitative test was obtained, but the amount was too small to determine.

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[a] These experiments were begun with Mr. E. S. Clowes, formerly assistant in the laboratory, and to whom I wish to express my thanks for his valuable assistance. It was our intention to extend our studies to other animals and to other conditions, but other work and Mr. Clowes's resignation have prevented this.

The following experiments show that in every case the animal which had received alcohol excreted a larger amount of sulphocyanate after corresponding amounts of the nitrile than did the normal. The guinea pigs on alcohol showed no ill effects whatever from the alcohol; they grew as rapidly and had as many young as the controls.

Date.	Weight of guinea pig.	Remarks.
	Grams.	
October 4, 1905	407	The food consisted largely of oats and bran soaked in 10 per cent alcohol; on about every third day a little green food was given.
October 10, 1905	430	Alcohol increased to 20 per cent.
October 20, 1905	470	Alcohol increased to 30 per cent.
November 2, 1905	467	
November 8, 1905	475	
November 14, 1905	460	
November 15, 1905	465	93 milligrams acetonitrile (0.2 milligram per gram weight). Survived.

On the first three days after the administration of the nitrile the following amounts of cyanogen were found in the urine:

Day.	Cyanogen.
	Milligrams.
First day	8.2
Second day	1.5
Third day	41.7
Total	51.4

Ninety-three milligrams acetonitrile (the amount injected) contains 58.96 milligrams cyanogen; hence about 87.2 per cent of the cyanogen of the nitrile appeared in the urine as sulphocyanate.

The control experiment was as follows:

Date.	Weight of guinea pig.	Remarks.
	Grams.	
October 4, 1905	410	Food as in preceding except that water was substituted for the alcohol.
October 10, 1905	425	
October 20, 1905	485	
November 8, 1905	475	
November 14, 1905	485	
November 15, 1905	490	98 milligrams acetonitrile (0.2 milligram per gram). Survived.

The excretion of cyanogen was as follows:

Day.	Cyanogen.
	Milligrams.
First day	6.2
Second day	23.8
Third day	1.5
Total	31.5

Ninety-eight milligrams acetonitrile (the amount injected) contains 62.13 milligrams cyanogen; hence 50.7 per cent of the cyanogen of the nitrile appeared in the urine as sulphocyanate.

Comparing this result with that of the alcohol experiment it will be seen that in the latter the excretion of sulphocyanate was 1.7 times as great as in the normal.

In the following experiment there were two controls; the administration of alcohol was continued for a longer period. The guinea pig on alcohol had been receiving dilute alcohol on its food from its birth eight months previously.

Date.	Weight of guinea pig.	Remarks.
	Grams.	
November 22, 1905	380	30 per cent alcohol on part of food.
November 29, 1905	365	
December 4, 1905	390	
December 9, 1905	405	
December 14, 1905	405	
December 21, 1905	431	
December 29, 1905	425	
January 2, 1906	....	Alcohol increased to 40 per cent.
January 5, 1906	450	
January 12, 1906	480	
January 16, 1906	....	Alcohol increased to 50 per cent.
January 19, 1906	520	
January 26, 1906	520	
February 2, 1906	540	
February 6, 1906	520	104 milligrams acetonitrile (0.2 milligram per gram). Survived.

The excretion of cyanogen was as follows:

Day.	Cyanogen.
	Milligrams.
First day	0.39
Second day	20.93
Third day	3.51
Fourth day	3.38
Fifth day	4.81
Sixth day	4.16
Total	37.18

One hundred and four milligrams açetonitrile contains 65.94 milligrams cyanogen; hence 56.3 per cent of the cyanogen of the nitrile was excreted as sulphocyanate.

The controls (of the same litter as the above) gave the following results:

Date.	Weight of guinea pig.	Remarks.
	Grams.	
November 22, 1905	330	Food as in foregoing, except for the alcohol.
December 4, 1905	375	
December 9, 1905	400	
December 14, 1905	405	
December 21, 1905	445	
December 29, 1905	435	
January 5, 1906	445	
January 12, 1906	475	
January 19, 1906	490	
January 26, 1906	515	
February 2, 1906	520	
February 6, 1906	500	100 milligrams acetonitrile (0.2 milligram per gram). Survived.

The excretion of cyanogen was as follows:

Day.	Cyanogen.
	Milligrams.
First day	4.03
Second day	.65
Third day	1.56
Fourth day	8.97
Fifth day	3.51
Sixth day	3.64
Total	22.36

One hundred milligrams acetonitrile (the amount injected) contains 63.4 milligrams cyanogen; hence about 35.2 per cent of the cyanogen of the nitrile appeared in the urine as sulphocyanate.

Comparing this result with that of the above alcohol experiment, it will be seen that the guinea pig on alcohol excreted about 1.65 times as much cyanogen as sulphocyanate as did the normal.

The other control experiment gave the following results:

Date.	Weight of guinea pig.	Remarks.
	Grams.	
November 22, 1905	295	
December 4, 1905	325	
December 9, 1905	355	
December 14, 1905	380	
December 21, 1905	425	
December 29, 1905	400	
January 5, 1906	390	
January 12, 1906	340	Had two young about this time.
January 19, 1906	345	
January 26, 1906	375	
February 2, 1906	400	
February 6, 1906	355	71 milligrams acetonitrile (0.2 milligram per gram). Survived.

The cyanogen excreted was as follows:

Day.	Cyanogen.
	Milligrams.
First day	3.38
Second day	2.99
Third day	3.51
Fourth day	1.17
Fifth day	1.56
Sixth day	2.34
Total	14.95

Seventy-one milligrams acetonitrile contained 45 milligrams cyanogen; hence 33.2 per cent of the cyanogen of the nitrile had appeared in the urine as sulphocyanate. Thus the guinea pig on alcohol had excreted 1.75 times as much cyanogen as sulphocyanate as did the normal after corresponding doses of the nitrile.

Another guinea pig of this series, which had received alcohol for several months (during which time its weight had increased from 345 to 520 grams), died from 95 milligrams acetonitrile (0.2 milligram per gram). And it may be remarked that a few other experiments were lost by the death of guinea pig receiving alcohol, for alcohol increased the susceptibility of guinea pigs to acetonitrile in the same way it did that of mice.

In the following experiments the excretion of cyanogen was less than in the foregoing, but a similar difference between the normal and alcohol animals was observed:

Date.	Weight of guinea pig.	Remarks.
	Grams.	
October 4, 1905	400	10 per cent alcohol on part of food.
October 10, 1905	420	
October 14, 1905	....	Alcohol increased to 20 per cent.
October 20, 1905	440	
October 24, 1905	....	Alcohol increased to 30 per cent.
November 2, 1905	435	
November 8, 1905	450	
November 14, 1905	460	
November 21, 1905	500	
November 28, 1905	490	Alcohol increased to 40 per cent.
December 3, 1905	530	106 milligrams acetonitrile (0.2 milligram per gram). Survived.

The excretion of cyanogen was as follows:

Day.	Cyanogen.
	Milligrams.
First day	10.5
Second day	7.4
Third day	5.5
Fourth day	4.8
Total	28.2

One hundred and six milligrams acetonitrile contains 67.2 milligrams cyanogen; hence 41.9 per cent had been excreted as sulphocyanate.

The control experiment was as follows:

Date.	Weight of guinea pig.	Remarks.
	Grams.	
October 4, 1905	385	Food as in the above, except for the alcohol.
October 10, 1905	410	
October 20, 1905	450	
November 8, 1905	450	
November 14, 1905	435	
December 3, 1905	505	101 milligrams acetonitrile (0.2 milligram per gram). Survived.

The cyanogen excretion was as follows:

Day.	Cyanogen.
	Milligrams.
First day	2.7
Second day	5.2
Third day	4.0
Fourth day	2.7
Total	14.6

One hundred and one milligrams acetonitrile contains 64 milligrams cyanogen; hence but 22.8 per cent of the cyanogen was excreted as sulphocyanate. The guinea pig on alcohol had converted 1.84 times as much of the cyanogen of the nitrile into sulphocyanate as the normal.

Thus in all of the above experiments the guinea pig which had been receiving alcohol excreted much more sulphocyanate after the administration of acetonitrile than did the normal; in most cases this excretion was about 1.7 times as great. The same results were obtained in a number of other experiments, the only exceptions being in a few experiments in which the alcohol guinea pig became very sick after the nitrile; in such cases there was either no greater excretion of sulphocyanate or there was a smaller excretion; but in all these experiments the guinea pig finally died, although death was sometimes delayed for a week.

The increased formation of sulphocyanate found in the above experiments with alcohol admits of two possible explanations: (1) there may have been an increased formation of sulphocyanate due to an increased breaking up of the acetonitrile molecule; or (2) equal amounts of sulphocyanate may have been formed, but normal animals may have the power of destroying more sulphocyanate. The latter supposition would be more in accord with the rather generally held view that oxidation processes are lowered by alcohol.

On the other hand, recent experiments by Pollak indicate that normal animals (dog, rabbit, man) destroy no sulphocyanate when this is administered as such.[a] My experiments on guinea pigs are in accord with Pollak's results with other animals in showing that there is no great destruction of sulphocyanate when given subcutaneously; and no difference was observed between normal and alcohol animals in this respect.

Fate of sulphocyanate in normal and alcohol guinea pigs.—My experiments with the subcutaneous injection of sodium sulphocyanate into guinea pigs were not very satisfactory, for although death did not result immediately there was usually much necrosis about the point of injection and death frequently occurred several days later.

Examples of such experiments are as follows: The first experiment was upon one of the guinea pigs which had been used for a nitrile experiment (see last experiment above); the alcohol had been

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[a] Hofmeister's Beit., v. 2, p. 430. A similar result had been obtained by Salkowski (Virchow's Archiv., v. 58, p. 460; 1873); Bruylants and Lang believed that much sulphocyanate was destroyed in the organism. The results of Pollak as regards the administration of sulphocyanate *per os* to man are in direct opposition to those of Edinger and Clemens (Zeit. für klin. Med. v. 59, p. 218); these authors found less than half of the sulphocyanate to be excreted.

continued from December 3. There had been an increase in weight, as shown below.

Date.	Weight of guinea pig.	Remarks.
	Grams.	
December 14, 1905	485	
December 21, 1905	570	
December 29, 1905	540	
January 2, 1906	568	170.4 milligrams sodium sulphocyanate (0.3 milligram per gram) subcutaneously. Died in 3 days, 14 hrs.; considerable necrosis about point of injection.

The excretion of cyanogen was as follows:

Date.	Cyanogen.
	Milligrams.
First day	24.8
Second day	6.7
Third day	6.4
Total	37.9

Thirty-seven and nine-tenths milligrams cyanogen corresponds to 118 milligrams sodium sulphocyanate; hence 69.3 per cent of the sodium sulphocyanate appeared in the urine.

The control (see above for early history) was as follows:

Date.	Weight of guinea pig.	Remarks.
	Grams.	
December 14, 1905	540	
December 21, 1905	600	
December 29, 1905	500	
January 2, 1906	602	180.6 milligrams sodium sulphocyanate (0.3 milligram per gram) subcutaneously. Recovered, but there was considerable necrosis about point of injection.

The excretion of cyanogen was as follows:

Day.	Cyanogen.
	Milligrams.
First day	33.8
Second day	8.3
Third day	0.0
Total	42.1

Forty-two and one-tenth milligrams cyanogen corresponds to 131.2 milligrams sodium sulphocyanate; hence 72.6 per cent of the sodium sulphocyanate injected had reappeared in the urine.

In the following experiments smaller doses of the sulphocyanate were given; there was but little necrosis.

Date.	Weight of guinea pig.	Remarks.
	Grams.	
December 11, 1905	200	Part of food soaked in 50 per cent alcohol.
December 18, 1905	205	
January 2, 1906	270	
January 8, 1906	325	
January 18, 1906	375	
January 25, 1906	400	
February 15, 1906	485	
February 28, 1906	545	
November 6, 1906	670	
November 11, 1906	630	126 milligrams sodium sulphocyanate (0.2 milligram per gram) subcutaneously. Survived.

The excretion of cyanogen was as follows:

Day.	Cyanogen.
	Milligrams.
First day	30.30
Second day	5.35
Third day	3.25
Total	38.90

Thirty-eight and nine-tenths milligrams cyanogen corresponds to 121.2 milligrams sodium sulphocyanate; hence 96 per cent of the sodium sulphocyanate was recovered from the urine.

The control was as follows:

Date.	Weight of guinea pig.	Remarks.
	Grams.	
December 13, 1905	150	Food as in the preceding experiment except for the alcohol.
January 2, 1906	225	
January 18, 1906	300	
February 15, 1906	385	
February 28, 1906	430	
March 23, 1906	490	
July 16, 1906	587	
October 6, 1906	670	
October 11, 1906	700	140 milligrams sodium sulphocyanate (0.2 milligram per gram) subcutaneously. Survived.

The excretion of cyanogen was as follows:

Day.	Cyanogen.
	Milligrams.
First day	32.35
Second day	2.60
Third day	4.64
Total	39.59

Thirty-nine and fifty-nine hundredths milligrams cyanogen corresponds to 123.4 milligrams sodium sulphocyanate; 88 per cent of the sodium sulphocyanate administered was therefore recovered from the urine.

In the following experiments the sodium sulphocyanate was administered *per os;* this method is unsatisfactory since the element of absorption from the intestinal tract is involved.

Date.	Weight of guinea pig.	Remarks.
	Grams.	
December 13, 1905	505	30 per cent alcohol on part of food.
December 29, 1905	435	
January 2, 1906	....	40 per cent alcohol on part of food.
February 2, 1906	510	
February 6, 1906	....	50 per cent alcohol on part of food.
March 5, 1906	450	
April 13, 1906	690	
June 22, 1906	620	
July 13, 1906	730	
September 17, 1906	710	213 milligrams sodium sulphocyanate (0.3 milligram per gram) *per os*. Survived.

The excretion of sulphocyanate (calculated as the sodium salt) was as follows:

Day.	Sodium sulphocyanate.
	Milligrams.
First day	75.33
Second day	27.14
Third day	8.51
Total	110.98

Thus 52.1 per cent of the sodium sulphocyanate administered *per os* reappeared in the urine in three days.

The control experiment was as follows: The guinea pig belonged to the same litter as the above and had been kept on the same food (with the exception of the alcohol) since December, 1905.

Date.	Weight of guinea pig.	Remarks.
	Grams.	
September 17, 1906	670	201 milligrams sodium sulphocyanate (0.3 milligram per gram) *per os.*

The secretion of sulphocyanate (calculated as the sodium salt) was as follows:

Day.	Sodium sulphocyanate.
	Milligrams.
First day	99.23
Second day	40.10
Third day	5.27
Total	144.60

In this case 71.9 per cent of the sulphocyanate administered *per os* reappeared in the urine; that is, the normal animal excreted more than the animal on alcohol, which is just the reverse of what occurs after the administration of acetonitrile.

The above experiments show that there is practically no difference between the amounts of sulphocyanate excreted by normal and alcoholic guinea pigs after the administration of sodium sulphocyanate; hence, the increased excretion by the guinea pigs on alcohol of sulphocyanate, after the administration of acetonitrile, most probably depends upon an increased formation of sulphocyanate, and hence upon an increased breaking up of the molecule of acetonitrile. Whether this increased breaking up of the acetonitrile is due to processes of oxidation (as I suppose to be the case) or to simple cleavage, it is impossible to state. In any case, the increased susceptibility of the alcohol animals is evidently connected with profound modifications of metabolic processes, and thus one case of increased susceptibility can be taken from the vague class of "lowered resistance" and a rational explanation offered.

While it may not be altogether justifiable to bring in Ehrlich's side-chain theory of immunity in this connection, yet this theory enables us to form a mental picture of how the tolerance for alcohol and the increased power to oxidize the methyl group of acetonitrile

might be brought about. If we suppose that alcohol is normally oxidized by reactive chemical groups analogous to side chains, then the tolerance may be thought of as due to an increase in the number of these groups and it is very natural to suppose that an organism that has acquired increased power of oxidizing the ethyl group of alcohol has also acquired increased power of oxidizing the methyl group of acetonitrile. This is but a suggestion; yet it should be remembered that Ehrlich proposed his side-chain theory of the structure of living matter in connection with his work on oxidation and sometime before he began his work on immunity.[a]

This explanation is very similar to the one recently suggested by Vaughan[b] for the "Rosenau-Anderson"[c] or "Theobold Smith"[d] phenomenon (the hypersusceptibility of guinea pigs to horse serum after a previous injection of horse serum). Vaughan supposes the proteid molecules (of horse serum, for example) to contain toxic groups; the first time the horse serum is injected the body breaks up the molecule but slowly, so that the toxic groups are set free slowly, and there are no symptoms of intoxication. But if a second injection is made after ten days "the cells tear the molecule to pieces quicker than before; this sets the poisons free quicker and the animal dies."

These experiments with alcohol and acetonitrile are of interest in another connection. The greatest advance in recent years in our knowledge of the physiological action of alcohol has been the clear demonstration that alcohol is oxidized in the body and may replace fats and carbohydrates and, to a certain extent, the proteids of an ordinary diet. So clear has been this demonstration that the view that alcohol, in moderate amounts, should be regarded as a food is almost universally accepted by physiologists, and the drift of opinion is certainly toward the view that it is in all respects strictly analogous to sugar and fats, provided always that the amount used does not exceed that easily oxidized by the body. Under these premises it would be expected that alcohol in a diet would have the same effect upon an animal's susceptibility to acetonitrile as has dextrose, for example. This is by no means the case, however; on the contrary, the action of these substances in this regard is entirely different. Mice fed upon oats soaked in a solution of dextrose or upon cakes containing considerable dextrose, or upon rice, show a very distinct increase in their resistance to acetonitrile; such mice

[a] Ehrlich, Das Sauerstoff-Bedürfniss des Organismus, 1885.

[b] Journ. Amer. Med. Assoc., v. 47, p. 1009; 1906.

[c] Bulletin No. 29, Hygienic Laboratory, 1906.

[d] Otto, V. Leuthold-Festschrift, 1906.

may recover from two or even three times the dose fatal to controls.[a] While these facts are not sufficient to justify the conclusion that in many cases alcohol has not a true food value, yet they are sufficient to indicate caution in applying, without further consideration, the brilliant and very exact results on the proteid sparing power of alcohol to practical dietaries.[b]

The method of experimenting pursued in the above, namely, the determination of the effect of the long-continued use of a drug upon the action of other drugs seems adapted to the study of other problems in pharmacology such as those dealing with effects of food preservatives, for example, where experiments made upon healthy men and animals with small doses have often led to as inconclusive results as similar experiments with alcohol.

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[a] It is probable that the explanation of the increased resistance to acetonitrile of animals fed largely upon carbohydrates is that such animals do not break up so much of the nitrile. Thus in experiments upon two dogs, one of which had been kept for some time upon a diet consisting largely of lean meat, the other upon a diet consisting largely of rice, lard, and sugar, the meat-fed dog excreted 1.8 times as much cyanogen in the form of sulphocyanate, after a given dose of acetonitrile, as did the carbohydrate-fed dog; the symptoms of poisoning were also more severe in the former. Proteids are generally held to increase certain physiological oxidations; hence the above results are in accord with the hypothesis that processes of oxidation are involved in poisoning by acetonitrile. The markedly increased resistance of animals receiving a limited amount of food (see experiments on mice above) may similarly be supposed to be due to a lowering of certain of the processes of oxidation in the body; in two experiments on guinea pigs which had received, for some time, a limited diet there was a decidedly smaller excretion of sulphocyanate after the administration of acetonitrile than in the normal animals. Upon such a diet the body seems to acquire the ability to limit the decompositon of this poison just as it does that of the consumption of proteids and energy in certain diseases (Krehl, Clinical Pathology, translation, p. 319). On the other hand it may be, as Mr. Clowes has suggested, that in the case of the large proteid diet the cyanogen, rather than the methyl group, should be considered; that is, that the organism accustomed to dealing with the nitrogen groups of proteids would attack the cyanogen group first, setting it free much more rapidly than it could be neutralized by sulphur.

[b] Chittenden (Med. News, v. 86, p. 721) also cautions against accepting, without reservation, the view that alcohol should be considered a food comparable with the carbohydrates; he bases this view upon Beebe's work on the effect of alcohol upon uric acid excretion which he interprets as showing that alcohol diminishes the oxidation of uric acid. Chittenden expresses his conclusions in the following forceful words: "However this may be, it is, I think, quite plain that while alcohol in moderate amounts can be burned in the body, thus serving as food in the sense that it may be a source of energy, it is quite misleading to attempt a classification or even comparison of alcohol with carbohydrates and fats, since, unlike the latter, alcohol has a most disturbing effect upon the metabolism or oxidation of the purin compounds of our daily food. Alcohol, therefore, presents a dangerous side wholly wanting in carbohydrates and fats. The latter are simply burned up to carbonic acid and water, or are transformed into glycogen and fat, but alcohol, though more easily oxidizable, is at all times liable to obstruct, in some measure at least, the oxidative processes of the liver, and probably of other tissues also, thereby throwing into the circulation bodies such as uric acid which are inimical to health; a fact which at once tends to draw a distinct line of demarcation between alcohol and the two nonnitrogenous foods—fat and carbohydrate."

II.

THE EFFECT OF ALCOHOL UPON THE SULPHUR OF THE URINE.

1. *Effect of alcohol upon the excretion of ethereal sulphates.*—The following experiments, although very incomplete, seem worth recording, for they bring out an action of alcohol which has apparently been but seldom noticed. Briefly stated, it is shown that the excretion of ethereal sulphates in the urine may be increased many times, both absolutely and relatively to the inorganic sulphates, by the administration, continued for some time, of alcohol. It was found, for example, that their absolute amount might be increased in the rabbit from 8 or 9 milligrams per day to over 100 milligrams, while the percentage of sulphuric acid excreted in this form might increase from 3 or 4 to 50.

There are a few statements in the literature on alcohol which might have suggested that such a result would be found. Edsall,[a] for example, found the urine in a number of cases of chronic alcoholism to contain large amounts of phenol, a substance usually excreted in combination with sulphuric acid; he was inclined to regard this as an indication that the liver had been injured by alcohol and so was unable to destroy as much phenol as normally.[b] De Schweinitz and Edsall[c] reported a number of cases of tobacco-alcohol amblyopia in which there were present in the urine abnormal amounts of indican, phenol, and of total ethereal sulphates; they concluded that toxic substances produced in the digestive tract probably have a part in the production of this form of amblyopia.

Herter in his Lectures on Chemical Pathology (p. 161) suggested that the gastritis[d] and motor disturbances following the abuse of alcohol may lead to increased putrefaction and that the products of the latter inflict injuries to the liver which may ultimately be a factor in the production of cirrhosis of the liver.

Experimental.[e]—The experiments were performed upon rabbits. The alcohol was introduced into the stomach by means of a soft rubber

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[a] Univ. of Penn. Med. Bull., v. 16, p. 436; 1903–4.

[b] That narcotic drugs may inhibit the ability of the liver to transform phenol was shown by Herter and Wakeman (Jour. Exper. Med., v. 4, p. 322; 1899), who found that less phenol could be recovered, by distillation, from the liver of a normal animal than from one which had been anæsthetized for a long time.

[c] Amer. Jour. Med. Sci., v. 126, p. 216; 1903.

[d] Jagie (Wien. klin. Woch., v. 19, p. 1058; 1906) found alcoholic gastritis and enteritis as the initial symptoms of cirrhosis of the liver in a large number of cases.

[e] A number of the earlier sulphate determinations in these experiments were made by Mr. M. B. Porch, formerly assistant in pharmacology, to whom I wish to express my thanks.

catheter; it was always warmed to the body temperature and diluted with water to about 25 per cent. The same food (cabbage and carrots) was given throughout the entire experiment; no attempt was made to determine the amount eaten. The urine was collected twice a day from a dish placed under the cage; the amount collected in twenty-four hours varied considerably. The sulphur determinations were made by Folin's method,[a] Gooch crucibles being used. Duplicate analyses were always made.

EXPERIMENT I.—*Rabbit, dark gray; alcohol daily after January 15.*

Date.	Weight in grams.	Alcohol.		Total S as SO_3 in milligrams.	Total sulphates as SO_3 in milligrams.	Inorganic sulphates as SO_3 in milligrams.	Ethereal sulphates as SO_3 in milligrams.	Percentage of sulphates as ethereal sulphates.
		In grams.	Grams per kilo.					
1905.								
Dec. 14	2,400							
Dec. 21	2,400							
Dec. 25	2,390							
1906.								
Jan. 2	2,320							
Jan. 8-9				442.5	[a] 279.2	269.9	9.3	3.3
Jan. 9-11					[b] 266.9	258.8	8.1	3.0
Jan. 15	2,270	6.81	3					
Jan. 21-22					59.7	34.0	25.7	43.0
Jan. 22-23					89.1	64.9	24.2	27.0
Jan. 24	2,070							
Jan. 26	2,040							
Feb. 7-8					189.7	175.9	13.8	7.3
Feb. 8-9					115.0	106.0	9.0	7.8
Feb. 9	2,090							

[a] 64.5 per cent of total S. [b] Mean of two days.

Thus, within a week after beginning the alcohol the absolute amount of the total sulphate had decreased markedly, but the ethereal sulphates had increased from 8 or 9 milligrams to about 25 milligrams; the percentage of sulphate excreted as ethereal sulphate had increased from about 3 to 43. The same dose of alcohol (3 grams per kilo) was continued daily (with the occasional intermission of a day) for three weeks; both the absolute and relative amount of ethereal sulphate fell. This effect may have been due to the establishment of tolerance for the alcohol.

[a] Jour. Biol. Chem., v. 1, p. 131; 1906. In working with rabbits' urine I have found it necessary to frequently renew the asbestos mats of the Gooch crucibles; otherwise they either allowed a little barium sulphate to pass through or the filtration, even with strong pressure, became extremely slow. I have found the method to work admirably with normal human and dog's urine.

EXPERIMENT II.—*Rabbit, black; alcohol daily after November 4.*

Date.	Weight in grams.	Alcohol. In grams.	Alcohol. Grams per kilo.	Total S as SO_3 in milligrams.	Total sulphates as SO_3 in milligrams.	Inorganic sulphates as SO_3 in milligrams.	Ethereal sulphates as SO_3 in milligrams.	Percentage of sulphates as ethereal sulphates.
1905.								
Nov. 2–3	2, 035	....	....	....	260.7	248.2	12.5	4.8
Nov. 3–4	....	....	....	....	281.6	270.6	11	3.9
Nov. 4	2, 020	4.04	2	....	....	....	....	....
Nov. 13	2, 075	....	....	....	....	....	....	....
Nov. 23	2, 120	....	....	....	....	....	....	....
Nov. 28	2, 230	6.7	3	....	....	....	....	....
Dec. 7	[a] 2, 350	9.4	4	....	....	....	....	....
Dec. 9	....	8.2	3.5	....	....	....	....	....
Dec. 18	2, 190	....	....	....	....	....	....	....
1906.								
Jan. 8–9	....	....	....	346	[b] 224.4	194.9	29.5	13.1
Jan. 9–10	....	....	....	365.2	[c] 239	212.8	26.2	10.9

[a] Had 6 young December 11. [b] 64.8 per cent of total S. [c] 65.4 per cent of total S.

In the following experiment there was a return of the ethereal sulphate excretion to normal when the alcohol was discontinued.

EXPERIMENT III.—*White rabibt; alcohol daily from October 8 to December 7.*

Date.	Weight in grams.	Alcohol. In grams.	Alcohol. Grams per kilo.	Total sulphates as SO_3 in milligrams.	Inorganic sulphates as SO_3 in milligrams.	Ethereal sulphates as SO_3 in milligrams.	Per centage of sulphates as ethereal sulphates.
1906.							
Oct. 5–6	2, 140	....	....	327.8	315.6	12.2	3.7
Oct. 6–7	....	....	....	225.2	210	15.2	6.8
Oct. 8	2, 150	4.3	2	....	....	....	....
Oct. 10	2, 060	....	....	....	....	....	....
Oct. 15	2, 140	....	....	....	....	....	....
Oct. 16–17	....	....	....	372.8	354.7	18.1	4.9
Oct. 18	2, 030	....	....	....	....	....	....
Oct. 19	2, 030	6.09	3	....	....	....	....
Oct. 20	2, 020	....	....	....	....	....	....
Oct. 23–24	2, 040	....	....	314	308.6	5.4	1.7
Oct. 25	2, 070	....	....	....	....	....	....
Oct. 30	2, 010	....	....	....	....	....	....
Nov. 5	2, 010	....	....	....	....	....	....
Nov. 6	2, 010	7.04	3.5	....	....	....	....
Nov. 10	1, 985	....	....	....	....	....	....
Nov. 15	2, 020	....	....	....	....	....	....
Nov. 15–17	....	....	....	[a] 194.8	145.5	49.3	25.3
Nov. 17–19	....	....	....	[a] 165.3	130.5	34.8	21.1
Nov. 19	2, 020	8.08	4	....	....	....	....
Nov. 22	1, 990	8.96	4.5	....	....	....	....
Nov. 25	1, 950	....	....	....	....	....	....
Nov. 26–7	....	....	....	180	135.6	44.4	24.7
Nov. 27–28	....	....	....	180	125.3	54.7	30.4
Nov. 30	1, 935	....	....	....	....	....	....
Dec. 4–6	....	....	....	[a] 200.6	96.7	103.9	51.8
Dec. 6	1, 920	....	....	....	....	....	....
Dec. 7	([b])	([b])	([b])	([b])	([b])	([b])	([b])
Dec. 15	2, 030	....	....	....	....	....	....
Dec. 15–17	....	....	....	[a] 186	182.3	3.7	1.9

[a] Mean. [b] Alcohol discontinued.

The rabbit used for the following experiment was very resistant to alcohol, and the characteristic urinary changes occurred only after the administration of large doses.

Experiment IV.—*Rabbit, brown; alcohol daily from October 10.*

Date.	Weight in grams.	Alcohol.		Total sulphates as SO_3 in milli-grams.	Inorganic sulphates as SO_3 in milli-grams.	Ethereal sulphates as SO_3 in milli-grams.	Per centage of sulphates as ethereal sulphates.
		In grams.	Grams per kilo.				
1906.							
Oct. 5	2,310						
Oct. 7–8				296.9	287.1	9.8	3.3
Oct. 8–9				180.2	175	5.2	2.9
Oct. 10	2,220	4.44	2				
Oct. 15	2,180						
Oct. 18–19				275.7	266.8	8.9	3.2
Oct. 20	2,190	6.57	3				
Oct. 25	2,240						
Oct. 30	2,280						
Oct. 31 – Nov. 1				438.6	424.8	13.8	3.1
Nov. 5	2,310						
Nov. 6	2,310	8.05	3.5				
Nov. 10	2,350			246	212.9	33.1	13.5
Nov. 15	2,140						
Nov. 16	2,140	8.56	4				
Nov. 19–20				194.8	159.1	35.7	18.3
Nov. 22	2,020	9.09	4.5				
Nov. 25	2,270						
Nov. 26	2,270	11.35	5				
Nov. 30	2,135						
Dec. 1–2				243.2	215.7	27.5	11.3
Dec. 2–3				214.	188.1	25.9	12.1
Dec. 5	2,170	11.94	5.5				
Dec. 10	2,100						
Dec. 13	2,140	12.84	6				
Dec. 15	2,150						
Dec. 18	2,220	14.43	6.5				
Dec. 20	2,150						
Dec. 20–21				175.1	124.1	51	29.1
Dec. 22	2,160	15.12	7				
Dec. 27	2,090						
Dec. 31	2,030						
1907.							
Jan. 3	1,880						
Jan. 4–5				[b] 58.2	42.5	15.7	27.0

[a] Died. [b] From urine for about ten hours before death.

Sulphate determinations were frequently made upon the urine of normal rabbits kept under the same conditions as those which were receiving alcohol, the object being to determine if prolonged confinement would cause any increase in the excretion of ethereal sulphates. The latter did not occur. There were some variations in both the absolute amount of ethereal sulphates and in the percentage, but these never reached the figures constantly obtained with rabbits receiving alcohol.

Results similar to the above were obtained in two experiments upon guinea pigs. Under the influence of alcohol the percentage of the ethereal sulphates increased from 1 or 2 to 30 or 37.

Discussion.—The most striking effect of alcohol shown in the above tables is the increase in the excretion of the ethereal sulphates.[a] We may now take up the question as to the probable cause of this increase.

The views as to the significance of the ethereal sulphates are not in entire accord. For some time after their discovery by Baumann they were generally held to be an index of the amount of intestinal putrefaction. The correctness of this interpretation was, however, sometimes questioned. Thus Schütz,[b] in 1901, called attention to the fact that a variable amount of these products are excreted in the feces and that another part is destroyed in the organism; hence but a part of those formed appear in the urine.

Very recently Folin[c] and Shaffer[d] have reported experiments tending to show that not all of the ethereal sulphate present in the urine comes from the absorption of the products of intestinal putrefaction. Thus Folin found the indican (one of the most prominent of the ethereal sulphates) to disappear from the urine entirely upon a starch and cream diet, while the absolute quantity of ethereal sulphates was reduced only to about one-half of the amount eliminated on a nitrogen-rich diet. Folin concludes from this and other observations: "The ethereal sulphates can only in part be due to intestinal putrefaction, and neither their absolute nor their relative amount can be accepted as an index of the extent to which putrefaction is taking place in the intestines." Folin drew his conclusions from observations upon normal individuals. While they seem to show clearly that there is normally excreted some ethereal sulphate which is not connected with intestinal putrefaction, yet there seems to be nothing in them contrary to the view that when the ethereal sulphates are largely increased in pathological conditions this increase is not due chiefly to increased intestinal putrefaction. It may be added that v. Tabora[e] and Koziczkowsky,[f] two of the latest writers on this

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[a] There was in nearly all cases a diminution in the total sulphate excretion. As the sulphate excretion is, generally speaking, parallel to the proteid katabolism, the above results indicate that a smaller amount of proteid was being katabolized under the influence of alcohol. In the absence of data concerning the intake of food, it is not possible to determine whether this result was due to the proteid-sparing power of the alcohol or to the animals eating less.

[b] Arch. f. Verdauungskrank., v. 7, p. 43.

[c] Amer. Journ. Physiol., v. 13, p. 99, 1905.

[d] Ibid., v. 17, p. 380, 1906.

[e] Dtsch. Arch. f. klin. Med., v. 87, p. 254, 1906.

[f] Zeit. f. klin. Med., v. 57, p. 413.

subject, found a parallelism, although not complete, between the excretion of total ethereal sulphates and of indican.

Pringsheim[a] has recently made a suggestion which is of special interest in this connection, namely, that after the administration of alcohol some of this is excreted as the ethyl ether of sulphuric acid.[b] His arguments and experiments, are, however, not at all conclusive. This is a point well worth further investigation, however.

Accepting what seems to be the most probable explanation of the great increase in the ethereal sulphates in the above experiments, namely, that they have their origin in increased intestinal putrefaction, we may now consider how such increased putrefaction may be caused by alcohol. Among the numerous conditions to which increased intestinal putrefaction has been attributed there are two of special interest in this connection—chronic intestinal catarrh and diminution of free hydrochloric acid in the stomach. Both of these are well-known results of the administration of alcohol. Thus, Friedenwald found a gradual reduction in free hydrochloric acid in the gastric contents of his experimental animals. The relation of the hydrochloric acid of the gastric juice to intestinal putrefaction has, however, been the subject of much discussion. The view of Kast, Wasbutzki, and Stadelmann that absence or diminution of hydrochloric acid in the gastric juice led to increased intestinal putrefaction was opposed by von Noorden, but was again accepted by Biernacki, Schmitz, and others. Schultz[c] in 1901 again brought up arguments against Kast's view; these have recently been criticised by v. Tabora,[d] who, from a number of careful experiments, concludes that the hydrochloric acid prevents to a certain degree intestinal putrefaction and that sub-acidity and anacidity as a rule favor it.

Assuming that the great increase in the excretion of ethereal sulphate in these experiments is to be interpreted as showing that alcohol leads to increased intestinal putrefaction, the question arises, Can any of the pathological effects of alcohol be ascribed to this; in other words, may some tissues or organs be injured by the products of this intestinal putrefaction? Attention has already been called to the work of de Schweinitz and Edsall in regard to the relation of the products of intestinal putrefaction to tobacco-alcohol amblyopia. Elschnig[e] has reported a series of cases in which there seemed to

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[a] Zeit. f. physikal. u. diät. Therapie, v. 10, p. 281; 1906.

[b] If this ether were formed it would doubtless be excreted unchanged in the urine, for Salkowski (Virchow's Arch., v. 66, p. 315) found that it undergoes no change in the body.

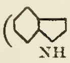
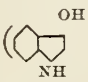
[c] Arch. f. Verdauungskrank., v. 7, p. 43.

[d] Deutsch. Arch. f. klin. Med., v. 87, p. 254; 1906.

[e] Elschnig, Münch. med. Woch., 52, No. 41, Oct. 10, 1905; Klin. Monatsh. f. Augenheilk., v. 43, p. 417; 1905.

be a parallelism between the amount of indican in the urine and various more or less severe eye disturbances. This entire subject has recently been discussed by de Schweinitz and others.[a] Certain other symptoms, such as some forms of headaches and neurasthenia, have, apparently with good reason, been attributed to these products; nephritis following intestinal obstruction has likewise been ascribed to the products of intestinal putrefaction.

The most interesting suggestion as to a possible pathological significance of the products of intestinal putrefaction is that they may have a part in the causation of cirrhosis of the liver. The view has often been expressed that cirrhosis of the liver is dependent in some way upon autointoxication from the digestive tract. Krawkow claimed to have obtained cirrhosis of the liver in fowls by the feeding of an infusion of putrid horse meat. One of the most definite suggestions in this connection is that of Boix,[b] who believed that the fatty acids formed as a result of gastritis were a factor in the causation of cirrhosis; he claimed to have obtained cirrhotic changes by the administration of butyric and acetic acids to animals.[c] There is, at present, no ground for supposing that those products (indol, skatol, phenol, etc.), which are usually considered the typical products of intestinal putrefaction, and which are largely responsible for the ethereal sulphates in the urine, have much significance in this respect; some of the most notable failures to produce cirrhosis of the liver experimentally have been in experiments upon rabbits; that is, upon animals in which alcohol readily leads to a great increase in the excretion of ethereal sulphates. This by no means excludes the possibility, however, that in some cases such products may contribute to such a result. Furthermore, evidence is gradually accumulating that indol, for example, which has ordinarily a very low degree of toxicity, may, under certain conditions, become distinctly toxic. Thus, Richards and Howland[d] found it decidedly toxic to animals whose powers of oxidation are lowered by potassium cyanide; similar results were obtained with phenol.

Recent experiments of Porcher and Hervieux[e] suggest another way in which the toxicity of indol may possibly become enhanced. These authors find indol () to be but very slightly toxic, while comparatively small amounts of indoxyl (), injected subcutane-

[a] Jour. Amer. Med. Assoc., v. 48, pp. 502, 543; 1907.

[b] Le foie des dyspéptiques, Paris Thesis, 1895.

[c] These conclusions have been recently unfavorably criticized by Goannoviecs (Arch. int., de Pharmacodynamie, v. 15, p. 241; 1905).

[d] Proc. Soc. Exper. Biol. & Med., v. 3, p. 71; 1905–6; cf. Herter, Medical Record, v. 70, p. 788; 1906.

[e] Jour. de Phys. et de Path. gén., v. 18, p. 841; 1906.

ously, are rapidly fatal. As is well known, indol, whether it be administered or be formed in the intestine, is normally excreted as indoxyl-sulphuric acid, which is also practically nontoxic. In other words, indol, before it can be excreted, is converted into the poisonous compound indoxyl. The latter is probably normally conjugated at once with sulphuric acid (or if present in large amounts converted into harmless precursors of indigo—not, according to these authors, into glycuronates), but it is conceivable that pathological conditions may arise which prevent this, and that then the indoxyl may have a deleterious effect.[a]

A systematic study of the excretion of ethereal sulphates, phenol, etc., in cases of alcoholism in man would probably yield interesting results. In a single observation upon a man with advanced alcoholic cirrhosis of the liver the urine contained 4.2 per cent of ethereal sulphates, which is lower than what is usually considered normal; unfortunately, data concerning the diet and the absolute amount of sulphates excreted were not available. It would have been interesting to have had phenol and indoxyl determinations in this case; it is possible that the liver had lost the power of neutralizing these poisons with sulphuric acid.[b]

2. *Effect of alcohol upon the neutral sulphur of the urine.*—As is well known, sulphur is constantly present in the urine in forms other than sulphuric acid. This is known as neutral or unoxidized sulphur and is made up of a very miscellaneous group of substances (sulphocyanates, cystin, taurin-derivatives, chondroitic sulphuric acid, oxy- and alloxyproteic acids, etc.). The taurin of the bile has long been quoted as an important source of the neutral sulphur. This view was based largely upon the work of Kunkel.[c] Recent experiments by Shaffer[d] throw much doubt upon the correctness of this conclusion, at least as far as man is concerned.[e] The elimination of neutral sulphur is not so closely dependent upon the sulphur of the food as is that of the sulphates.[f]

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[a] A suggestive illustration of the cumulative effects of two substances may be found in the relation of a large meat and alcohol diet to gouty manifestations. According to interesting observations made in Italy, neither the consumption of meat alone nor of alcohol with a low meat diet has a special tendency to lead to gouty attacks. Such a result, however, occurs frequently with a diet containing both. (Wood, Therapeutics, 12th ed., p. 308; 1905.)

[b] Edsall (l. c. and Boston Med. and Surg. Jour., v. 156, p. 181; 1907) believes that the increase in the ethereal sulphates, which is usually interpreted as indicating increased intestinal putrefaction, may be due, in part, to abnormalities in the liver, excretory, or various other organs.

[c] Pflüger's Archiv., v. 14, p. 344; 1877.

[d] Amer. Journ. Physiol., v. 17, p. 374; 1906.

[e] It is interesting to note in this connection that Kunkel did not include the ethereal sulphates with the total sulphates.

[f] Folin, Amer. Journ. Physiol., v. 13, p. 99, 1905; cf. Shaffer, l. c.

In my experiments, alcohol seemed to have but little effect upon the percentage of sulphur excreted as neutral sulphur. Thus, in Experiment I (see above), the neutral sulphur amounted to 35.5 per cent of the total sulphur excreted by a normal rabbit. In Experiment II, after the animal had received alcohol for over two months (the diet being otherwise the same), and there had been a marked increase in the excretion of ethereal sulphates, the neutral sulphur constituted approximately 35 per cent of the total sulphur. Two other experiments gave similar results; the percentage of sulphur excreted as neutral sulphur varied in the normal rabbit from 32.3 to 34.3, and in the rabbit receiving alcohol from 30.4 to 31.3 per cent.

In a case of advanced alcoholic cirrhosis of the liver (man) 7.3 per cent of neutral sulphur was found; this figure is very similar to those obtained by Folin and Shaffer for men on a high proteid diet. Unfortunately no data as to the diet in this case, which is of such importance, are available.

An increased excretion of neutral sulphur is frequently interpreted as indicating a diminution of physiological oxidation. Some of the arguments for this view are furnished by the work of Reale and Boeri,[a] who found the neutral sulphur of the urine increased when the respiration was interfered with mechanically, and by the work of Harnack and Kleine [b] on the effects of alkalis and chloral hydrate on the excretion of neutral sulphur. The results of my experiments with acetonitrile are probably to be similarly interpreted; in poisoning by this substance the percentage of neutral sulphur frequently rose from 25 to 65 or more; the total sulphur excretion was not much changed but the oxidized sulphur frequently almost disappeared. Part of the increased neutral sulphur was contained in the sulphocyanate formed from the nitrile, but the great decrease in the sulphates suggests that physiological oxidations had been lowered by the nitrile. Returning to the experiments with alcohol: This substance did not cause an increase in the excretion of neutral sulphur; this may be considered as another argument that alcohol has but a limited power of inhibiting "physiological oxidations." [c]

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[a] Reale and Boeri, Wien. med. Woch., 1895, p. 1198.

[b] Harnack and Kleine, Zeit. f. Biol., v. 37, p. 417; Kleine, Inaug. Diss., Halle; 1895.

[c] Inasmuch as no one seems to have recorded sulphur determinations in the urine of guinea pigs it may be of interest to note that these animals, receiving a diet consisting largely of carrots and cabbage (as did the rabbits) excreted from 25 to 35 per cent of the sulphur as neutral sulphur. This ratio was not changed in animals inoculated with tubercle bacilli.

Kittens receiving a diet of bread and milk excreted from 25 to 30 per cent of the sulphur as neutral sulphur. A dog receiving a diet consisting almost entirely of lean meat excreted from 23 to 29 per cent of the sulphur as neutral sulphur; one on a diet consisting largely of rice, lard, and sugar excreted from 64 to 65 per cent in this form.

In a case of acute catarrhal jaundice (man) 15 per cent of the sulphur was in the neutral form; this figure is lower than that frequently found, but in the absence of data as to diet the figures have not much value. There was 16.4 per cent of ethereal sulphates in this case.

TREASURY DEPARTMENT.

Public Health and Marine-Hospital Service of the United States.

WALTER WYMAN, Surgeon-General.

HYGIENIC LABORATORY.—BULLETIN No. 34.

M. J. ROSENAU, Director,

MAY, 1907.

I. *Agamofilaria georgiana* n. sp., an Apparently New Roundworm Parasite from the Ankle of a Negress.

II. The Zoological Characters of the Roundworm Genus *Filaria* Mueller, 1787.

III. Three New American Cases of Infection of Man with Horse-hair Worms (species *Paragordius varius*), with Summary of all Cases reported to date.

BY

CH. WARDELL STILES.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1907.

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WALTER WYMAN, *Surgeon-General*,
United States Public Health and Marine-Hospital Service.

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CONTENTS.

SUMMARY.

This bulletin contains three articles on parasitic worms found in man.

In the first article a new species (*Agamofilaria georgiana*) of roundworm, apparently belonging to the family *Filariidæ*, is described. This very interesting, immature parasite, measuring 32 to 53 mm. in length, was taken from the ankle of a negress at Darien, Ga. Its mouth is surrounded by two small lateral papillæ and four submedian lip-like papillæ. The anatomy is described so far as the material permitted. Nothing is known of its life history.

The second paper contains a summary of the zoological characters of the genus *Filaria*, so far as known, and a list (with synonymy) of the roundworms of the family *Filariidæ* which have been reported for man. It is shown that zoologically this group is in a very unsatisfactory condition systematically.

In the third paper all of the cases of infection of man by horsehair worms (*Gordiidæ*) are brought together and three unpublished cases are reported. The conclusion is drawn that the popular dread of these worms is not well founded, for they are rare, accidental, and as a rule, at least, not dangerous parasites in man. The common species in this country is *Paragordius varius*.

The illustrations for these three papers have been prepared by Mr. Leonard Wilder.

All bibliographic references are taken from Stiles & Hassall, Index-Catalogue of Medical and Veterinary Zoology.

AGAMOFILARIA GEORGIANA N. SP., AN APPARENTLY NEW ROUNDWORM PARASITE, FROM THE ANKLE OF A NEGRESS.[a]

By Ch. Wardell Stiles, Ph. D.,

Chief of Division of Zoology, Hygienic Laboratory, U. S. Public-Health and Marine-Hospital Service.

(Figs. 1–25.)

Eighteen specimens of a nematode worm (figs. 1–2) have been forwarded to this laboratory by Dr. St. Joseph B. Graham, of Savannah, Ga., with the history that they had been taken from a sore on the leg of a negress at Darien, Ga. All of the specimens are immature; they are not especially well preserved, and on this account they have presented considerable difficulty in technique and interpretation. Accordingly, it has been impossible to give a complete description of the species. But as the worm seems to be a new parasite for man, and as certain points in the anatomy could be recognized, it seems advisable to place the parasite on record, notwithstanding the fact that several important points are open to different interpretations and that the description is therefore necessarily incomplete.

Medical history of the case.—For the following medical history of the case I am indebted to Dr. P. S. Clark:

> In August, 1896, I was called to see a negress; age, 57; occupation, washerwoman. I found her suffering with pain and swelling in and around her left ankle and instep. She said she could feel something moving in the swollen places, but there was no abrasion on the skin. I gave her a linament with which to rub the affected parts. This did not seem to be of much benefit. She continued to suffer for twelve or eighteen months, when suddenly she discovered a worm coming out of the most swollen place; and worms continued to appear singly at intervals for a month, when the opening healed and the pain and swelling subsided, her foot became entirely well, and gave no further trouble. She died in 1903 of tuberculosis of the lung. I think there were as many as two or three dozen of these worms extruded from this opening during the above-mentioned period.

[a] By permission of the Surgeon-General, and in response to an invitation, this paper was presented at the annual meeting of the American Society of Tropical Medicine, at Philadelphia, Pa., March 27, 1906.

Patient was never confined to bed as the result of the above condition. I preserved some of the worms in alcohol and gave them to my friend, Dr. Ralston Lattimore, of Savannah, Ga., as a zoological curiosity, who in turn handed them to Dr. St. Joseph B. Graham, of Savannah, who was kind enough to send some specimens to you for study and identification.

Systematic position.—The worms in question would probably be classified by many authors as a *Filaria*. Such classification is, however, not satisfactory, for in the absence of the adult stage it is difficult to determine to what group of the *Filariidæ* the parasites may belong. To place the species in *Filaria* would be adding confusion to an already very confused genus. Possibly these worms belong in *Tetracheilonema*,[a] but too little is known about the type species of this genus to justify a definite opinion.

As the most satisfactory solution of the systematic dilemma which presents itself, I propose to classify these parasites under the collective term—

AGAMOFILARIA new name.

Diagnosis.—*Filariidæ:* A purely collective group, to contain agamic forms of *Filariidæ*, which have not yet reached a stage in their development permitting of their being determined generically. Such a group has no type-species. Compare *Agamodistomum*, *Amphistomulum*, *Agamomermis*, *Merminthoidum*, *Agamonematodum*, etc.

As the species under consideration does not seem to be identical with any form described for man, and as it is not apparent at present that it is identical with any species described for other hosts, I propose to recognize it as a new species under the name *Agamofilaria georgiana*, with the following characters:

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[a] *Tetracheilonema* Diesing, 1861a, 621, 711 (Dec. 6, 1860) (m. *quadrilabiatum*).

Generic diagnosis.—*Filariidæ:* "Corpus longissimum, filiforme. Caput quadrilabiatum, labiis in quadrangulum dispositis. Os ad basin labiorum. Extremitas caudalis spiraliter torta. Penis vagina tubulosa. Apertura genitalis in anteriore corporis parte; uterus ——— Vivipara.—Avium brasiliensium in cavo abdominis et sub cute colli endoparasita."—Diesing, 1861a, 711.

The type species presents the following synonomy and diagnosis:

Tetracheilonema quadrilabiata (Molin, 1858) Diesing, 1861.

1858: *Filaria quadrilabiata* Molin, 1858, 417 (in *Tinamus rufescens*, at Caiçara; and *T. maculosus*, in Brazil).—Diesing, 1861a, 711.—Stossich, 1897, 77.

1858: *F. tinami* M. C. V., MS., in Molin, 1858, 417.

1861: *Tetracheilonema quadrilabiatum* (Molin, 1858) Diesing, 1861a, 711.—Stossich, 1897, 77.

Specific diagnosis.—*Tetracheilonema:* "Os quadrilabiatum, labiis conicis, magnis; corpus inflexum; extremitas anterior sensim attenuata; posterior spiraliter torta; extremitas caudalis maris attenuata, obtusa; vagina penis tubulosa, extremitate libera incrassata; penis ———; extremitas caudalis feminæ attenuata, obtusa. (Vivipara.) Longit. mar $1\frac{1}{4}$–$1\frac{1}{3}''$ [30 to 33 mm.]; crassit, $\frac{1}{3}'''$. Longit. fem., $1\frac{1}{2}$–$2''$ [36 to 50 mm.]; crassit, $\frac{1}{2}'''$.

"Habitaculum.—*Tinamus rufescens*, Novembri, Caiçara: in cavo abdom.—*T. maculosus*, in Brasilia: sub cute colli (Natterer). M. C. V."—Molin, 1858, 417.

AGAMOFILARIA GEORGIANA, new species.

(Figs. 1 to 25.)

1906: A new species of parasite in man, Stiles, 1906, Apr. 21, 839–840, N. York M. J. (1429), v. 88 (16); 1906, Apr. 21, 1232, J. Am. M. Ass., Chicago, v. 46 (16).

Specific Diagnosis.—*Agamofilaria:* Adults unknown.

Agamic form: Length 32 to 53 mm. Body cylindrical, of more or less uniform diameter the greater part of the length, with a maximum diameter of about 560 to 640 μ; gradually attenuated toward both extremities, slightly more gradually cephalad than caudad. Mouth terminal, central, circular, small, unarmed, but surrounded by six papillæ. Four of these are prominent, submedian, 23 μ elevations, having in some cases almost the appearance of lips; two smaller papillæ are latero-median. Anus a transverse slit, about 44 to 56 μ in transverse diameter, situated ventrally, 64 to 128 μ from end of tail. Tip of tail provided with a small conical projection 8 to 13 μ long by 4 μ in diameter. Excretory pore 0.432 to 0.520 mm. from anterior end. Cuticle in general without transverse striation, except for a fine transverse striation in the anal region, especially postanal, and a (probably pseudo-) striation in the esophageal region. Median lines visible externally in glycerine specimens merely as lines of demarcation between the muscular fields; on section, median bands are very slender, but are visible, and extend centripetally below the muscles, widening in breadth. Lateral bands rather prominent, and may be traced practically the entire length of the worm; they may attain a breadth of 96 μ, but they decrease in breadth cephalad (to about 15 μ) and caudad; they are divided into a dorsal and a ventral portion, which are not necessarily symmetrical and which are separated by a distinct line of single, subcuticular cells; the cells of the lateral bands are chiefly subcuticular, but near the head they extend centripetally in a single row in each half. Attached to the lateral bands, and hanging into the body cavity each side is a sinuous, longitudinal ridge, resembling the head-glands of strongyles, and provided with a central longitudinal canal which empties at the excretory pore; in the bridge of the esophageal region this glandular structure possesses a large apparently unilateral nucleus (296 to 316 μ by 90 to 132 μ), situated latero-ventrally. Esophagus simple, 2.5 to 2.9 mm. long, 88 to 114 μ in diameter (anteriorly) to 334 μ in diameter (posteriorly); its lumen is triradiate, each ray measuring about 10 μ. Chyle intestine straight, or very nearly so, rather large, at first compressed laterally, then rather quadrangular, with fibers running from the submedian lines toward the body wall; farther caudad it becomes flattened dorso-ventrally, measuring about 300 μ transversely by about 200 μ dorso-ventrally; its cells are columnar, about 9 μ in diameter by 30 to 90 μ high; the cuticle of the lumen is about 6.6 to 8.8 μ thick. Rectum about 200 μ long. Body cavity almost completely occupied by the intestine, lateral, longitudinal glands, and a reticular structure extending centripetally from the muscles toward the intestine; a considerable amount of granular material also present (? some of this possibly representing the primordium of the genital glands).

Habitat.—Agamic form taken from superficial sores on the ankle of a negress (*Homo sapiens africanus*), at Darien, Georgia, U. S. A. Life history and source of infection known.

Type Material.—U. S. P. H. & M. H. S., No. 9726.

The following details were observed:

GENERAL EXTERNAL CHARACTERS.

Size.—The worms (figs. 1–2) vary in length from 32 to 53 mm., the eighteen specimens giving the following measurements: 32 mm., 34 mm., 36 mm., 37 mm., 38 mm., 40 mm., 42 mm., 45 mm., 47 mm., 49 mm., 50 mm., 52 mm., and 53 mm.

In the longest specimen (53 mm.) the cephalic extremity is bluntly rounded; 80 μ caudad of the mouth it is 128 μ in diameter; it swells gradually to 368 μ in diameter a short distance caudad of the posterior end of the esophagus.

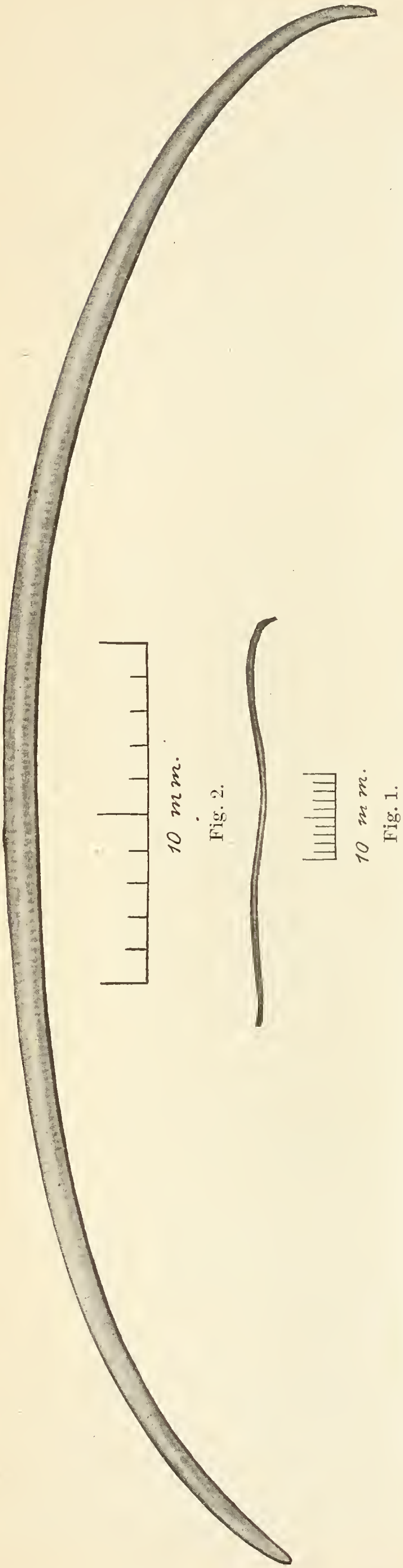


Fig. 1.—*Agamofilaria georgiana* from ankle of a negress at Darien, Georgia. Natural size. Fig. 2.—Specimen of same, enlarged 4 times.

In the specimen 44 mm. long, the diameter is 160 μ at a point 80 μ back of the mouth; the maximum diameter is 560 μ.

In the specimen 37 mm. long, the diameter 80 μ back of the mouth is 136 μ; at 800 μ back of the mouth the diameter is 272 μ; 1.6 mm. back of the mouth the diameter is 368 μ; the increase is then rather gradual, and at the end of about the first third of the specimen the diameter attains 560 μ; then a diameter of 576 μ is retained more or less uniformly, but with a slight variation, at some points reaching 624 μ; toward the tail, the diameter begins to decrease, at first slowly, then more rapidly; at 1.6 mm. from the tip, it is 400 μ; at 800 μ it is 272 μ (dorso-ventral diameter); at the anus the dorso-ventral diameter is 120 μ; the tail then ends rather bluntly.

In a mounted specimen 32 mm. long, the diameter 80 μ back of the mouth is 128 μ; at 800 μ it is 240 μ; just before the end of the esophagus it is 432 μ; just back of the esophagus there is a slight constriction, to 400 μ; it then varies between 560 and 640 μ for the greater part of the length; near the tail it begins to decrease, reaching 432 μ at a point 1.6 mm. from the tip; it now decreases more rapidly, reaching 240 μ at a point 800 μ from the tip; at the anus, the dorso-ventral diameter is 80 μ.

In general, the body may attain a maximum diameter of about 560 to 640 μ and is more or less uniform for a considerable part of its

length; it tapers gradually toward both extremities, the attenuation toward the head being slightly more gradual than that toward the tail.

Torsion of the body.—These specimens present a torsion around the longitudinal axis, so that when the head is viewed dorsally, the anus of the specimen is shown in profile; when the specimen is so placed on a slide as to give a ventral view of the anus, the head is seen in profile.

Head.—The head (figs. 3–5) is rather bluntly rounded, without any indication of a cephalic cone. The small terminal, central, circular mouth is surrounded by six papillæ, which are directed forward.

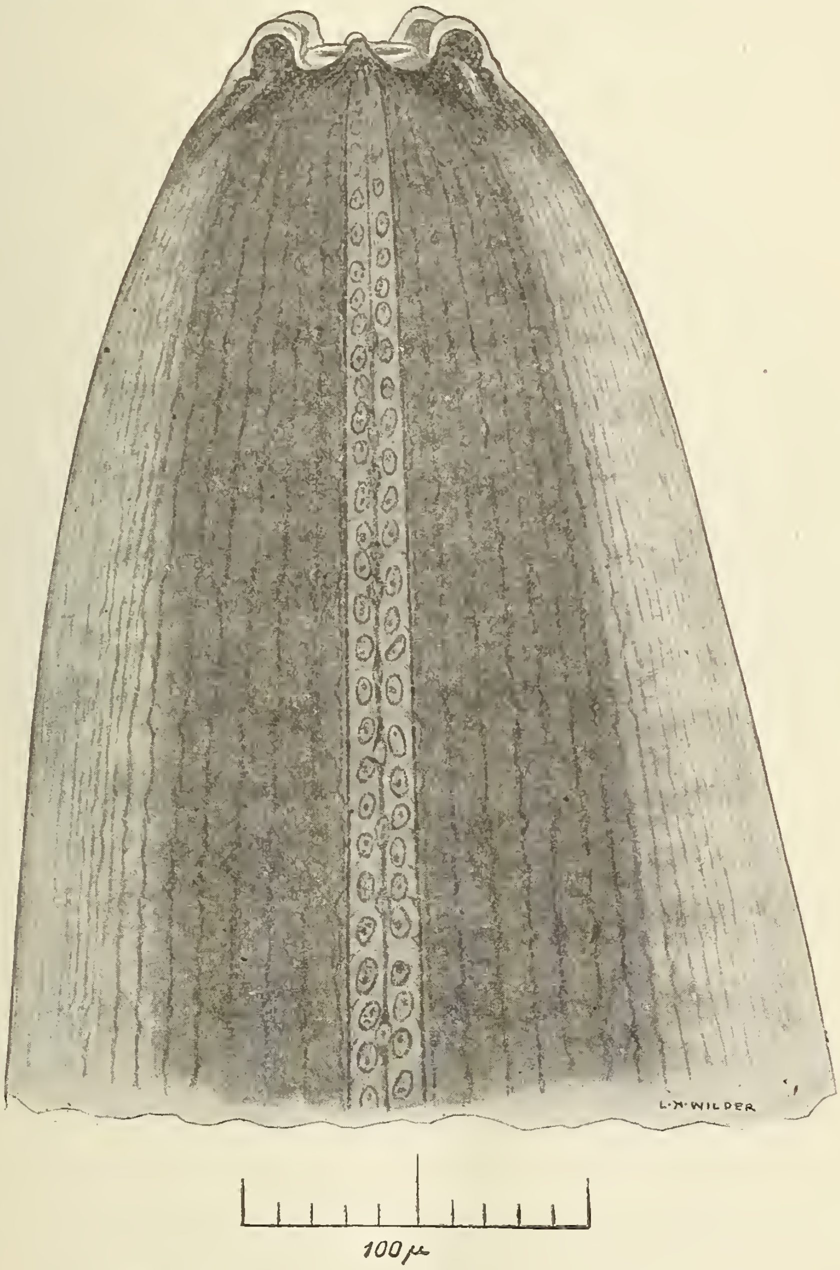


Fig. 3.—Head of same; greatly enlarged lateral view, showing the mouth surrounded by two small lateral papillæ and four larger submedian lip-like papillæ; note the lateral line with its two distinct rows of nuclei (one dorsal and one ventral), and a third, middle row of less distinct nuclei separating the others; note also the longitudinal striation due to the somatic muscles; the darker field is caused by the underlying esophagus.

Two of these papillæ are small and latero-median. Four of the papillæ are submedian and are much larger than the latero-median papillæ; they bear some resemblance to lips, and frequently show a larger,

clearer portion, situated closer to the mouth, and of more lip-like appearance (fig. 4), and a smaller, darker, external ridge, which appears of more distinctly papillary nature; from base to tip these larger lip-like papillæ measure about 23 μ. There is some variation in the specimens, due possibly to their condition, which makes it difficult to infer just how these papillæ would appear in perfectly fresh or in well-preserved material. Extending caudad from the more strictly papillary portion (the external ridge), in several cases structures were seen which were strongly indicative of nerves.

Cervical papillæ have not been observed.

The *excretory pore* is small, medio-ventral, not prominent, 0.432 to 0.52 mm. from the anterior end.

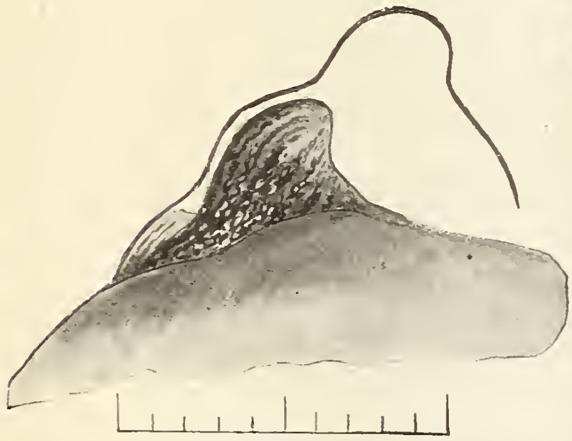


Fig. 4.

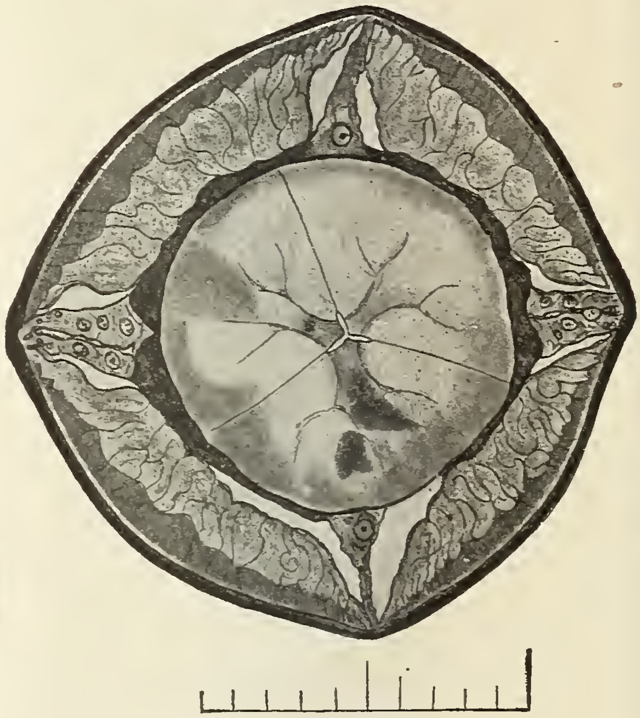


Fig. 5.

Fig. 4.—Greatly enlarged profile view of one of the submedian lip-like papillæ, showing the lip-like projection near the mouth and the external papillary portion.

Fig. 5.—Enlarged transverse section of head, close to the mouth. Note the following points: The cuticle seems to present two layers; it shows thickenings near the lateral lines; immediately under the cuticle, the thin subcuticula is visible as a light line extending around the body; at the four longitudinal lines (dorsal, ventral, and two laterals) the longitudinal bands are seen, extending toward the esophagus, and connected by a circular bridge which surrounds the esophagus; the lateral bands are thicker than the median bands, and present a dorsal and a ventral half; each half shows a row of nuclei; besides these a single middle nucleus is seen; the muscles are divided into four quadrants by the longitudinal bands; centripetally of the more darkly colored contractile muscular layer the protoplasmic processes extend toward the esophagus, forming a mesh work; the esophagus is central and shows a triradiate lumen and radial symmetry.

Tail.—The profile of the tail (figs. 7–9) is not uniform, but it bends slightly ventrad. In one mounted tail the transverse diameter at the anus is 128μ; in one mounted tail the dorso-ventral diameter at the anus is 80μ; and in one unmounted specimen, the dorso-ventral diameter at the anus is 120μ. In these three specimens, the anus is 96, 64,

and 80μ, respectively, from the tip of the tail; in two other specimens it is 104μ and 128μ, respectively, from the tip. The anus is a transverse slit about 44 to 56μ in transverse diameter.

At the apex of the tail, there is a small conical projection, 8 to 13.4μ long, 4.4μ in diameter; this may be curved slightly dorsad and is not equally prominent in all specimens.

Cuticle.—The cuticle at the anterior portion of the body is not so thick (about 3μ) as that (about 4 to 6μ) over the greater part of the worm (measurements taken from sections and also from worms). In general it shows no transverse striation; at the tail, however, quite a distinct but fine striation is visible in the postanal portion and in one

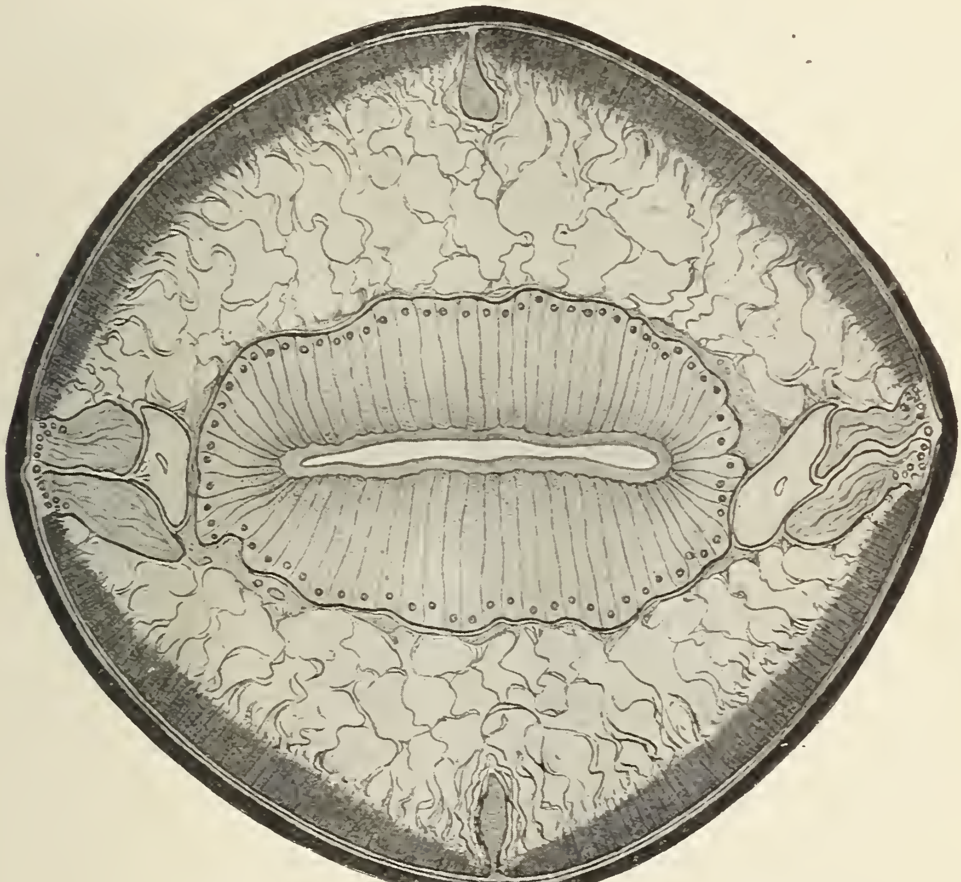


Fig. 6.—Enlarged transverse section of body through midgut region. Note the following details: The cuticle appears in two layers and presents four distinct thickenings, two near each lateral line; the subcuticula is visible between the cuticle and the muscles; the narrow dorsal and ventral median bands extend into the body cavity beyond the muscle layer and then increase in breadth; the division of the lateral bands into a dorsal and a ventral half is very distinct; near the cuticle, in the space between them, is seen a nucleus; nuclei are also visible in each half near the cuticle; the four muscular fields and the centripetal reticulum are very evident; the intestine is compressed dorsoventrally, and presents a high columnar epithelium with centrifugal nuclei and centripetal cuticular lining; between the lateral bands and the intestine is seen, each side, a section of the excretory gland, with its central canal.

specimen these striæ may be followed cephalad to the plane of juncture of the rectum with the chyle intestine; some of the specimens also show a transverse striation in the esophageal region, but this is probably a pseudostriation, as it is not constant and as it is most prominent on one specimen in which the head is rather strongly curved.

A distinct longitudinal striation is visible upon microscopic examination; this is due, not to any striation in the cuticle but to the longiudinal somatic muscles.

Longitudinal lines.—The lateral bands are prominent, but externally the dorso- and ventro- median bands are barely recognizable; the position of the latter may, however, be distinguished externally, midway between the lateral bands, as longitudinal lines, at which the somatic muscles are thinner than usual, and in fact at which the respective muscle cells are slightly interrupted; the median lines may, however, be described as practically invisible externally; on section they are seen to be very narrow centrifugally, but slightly broader centripetally.

Lateral bands.—The lateral bands may be traced the entire length of the worm, from a point immediately back of the latero-median papillæ

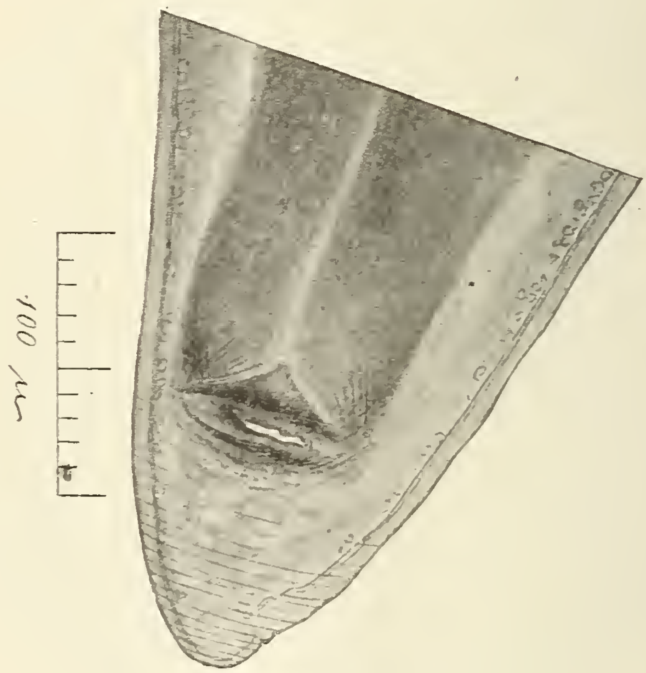


Fig. 7.

Figs. 7–9.—Enlarged ventral (7) and lateral (8 to 9) views of the tail. Note the transverse striation in the post-anal portion; the broad transverse anal slit; the midgut is large, but the rectum is compressed dorsoventrally; the lateral band, with numerous nuclei, is prominent; various cells, nuclei, and muscles are seen.

at the anterior end to the end of the tail; in the esophageal region they are somewhat less distinct than in the midgut region. Very close to the mouth, in one specimen, the lateral band measures 15μ broad and shows two distinct and one rather indistinct row of nuclei directly under the cuticle; sections, however, show other nuclei farther away from the cuticle; in one section very near the mouth, the band measured 13.2μ dorso-ventrally; the band increases gradually in breadth; at the posterior end of the esophagus in one worm it measures 45μ; in one specimen, it is 56μ and in another specimen 88μ at this point; at the equator of the worm it measures 90μ; it retains this breadth more

or less uniformly to within a short distance from the anus, when it gradually decreases in actual breadth, although it may increase in relative breadth, owing to the decrease of the dorso-ventral diameter of the worm. The greatest breadth of the lateral band noticed in any specimen was 96μ. In one specimen it measured 30.8 at the anal plane.

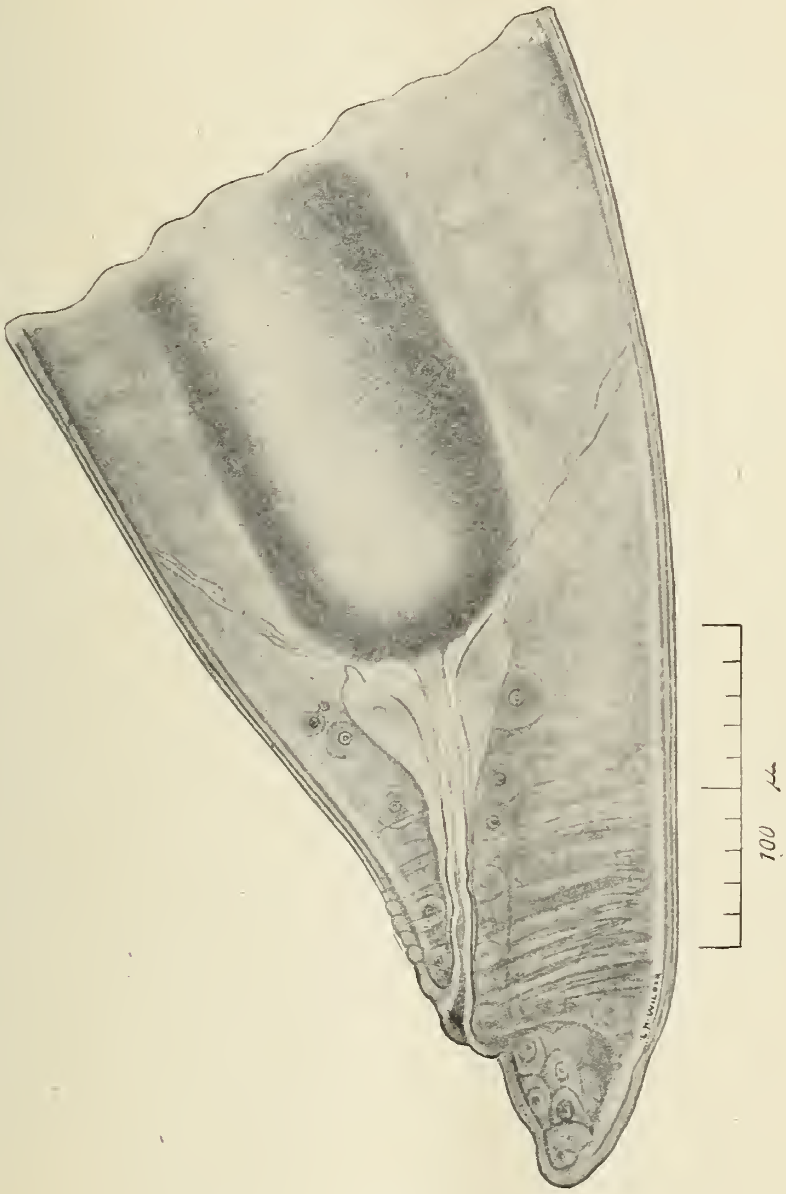


Fig. 8.

INTERNAL STRUCTURE.

Not an inconsiderable amount of the anatomy can be seen in specimens cleared in glycerine, but for an interpretation of some of the structures sections are necessary.

Digestive system—The intestinal canal consists of three distinct portions: a long undivided esophagus; a long chyle-intestine (midgut), and a distinct rectum.

Esophagus.—The esophagus (figs. 5, 10, 11, 15) is 2.5 to 2.9 mm. long; anteriorly it is 88 to 114μ in diameter; caudad it increases in diameter, at first slowly, then more rapidly, attaining its maximum

(about 334μ) slightly in front of its caudal end. The measurements of the esophagus vary in different specimens. No differentiation into the dispharagus type was observed. A torsion of the esophagus is present. In its caudal half and at some other points the esophagus lies more or less exactly in the middle axis of the body, but portions of its anterior half may be decidedly excentric, nearing the dorsal surface of the worm. On section the outline is circular, but the lumen is seen to be triradiate, each leg of the 3-rayed star measuring about 10μ. The body of the

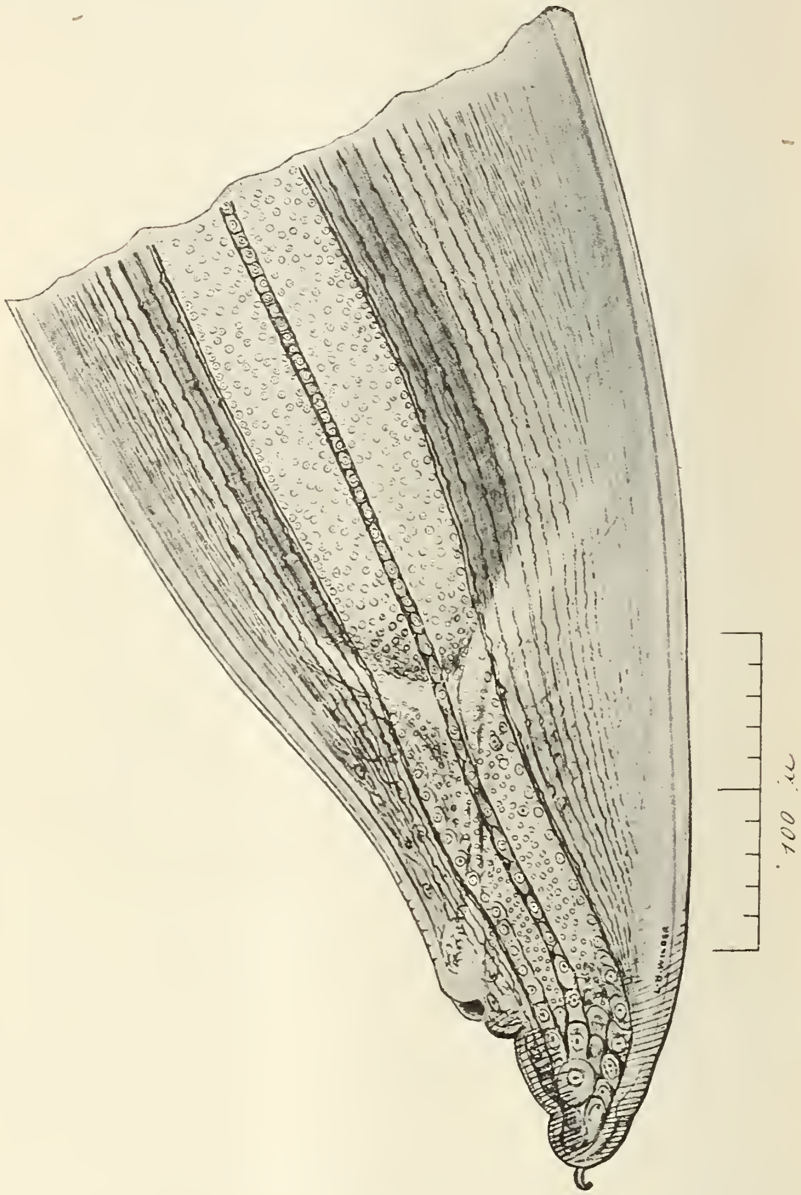


Fig. 9.

esophagus (figs. 5, 11) presents an exceedingly interesting arrangement of its component parts, but because of the poor condition of the material it is perhaps better not to attempt a definite interpretation at this time. It may, however, be stated that nuclei are visible at some points and that at other points there are structures which are indicative of nerves and of glands; further, that the component parts of the esophageal wall present an almost mathematically exact radial symmetry, the three chief fields of the symmetry being determined of course by the three legs of the triradiate lumen; finally, the component parts

of each of these three fields present a more or less exact symmetry. The esophagus is more or less surrounded by certain structures, which will be described farther on.

Chyle-intestine.—The chyle-intestine or midgut (fig. 13) is of nearly uniform diameter and runs straight from the posterior end of the esophagus to the anterior end of the rectum. Focusing upon the chyle-intestine through the body wall, one distinctly sees the bases of the intestinal cells; they are about 9μ in diameter and arranged much like the cells of a honey-comb.

Viewed in transverse section the chyle-intestine is seen to be at first somewhat compressed laterally, then it becomes rather quadrangular,

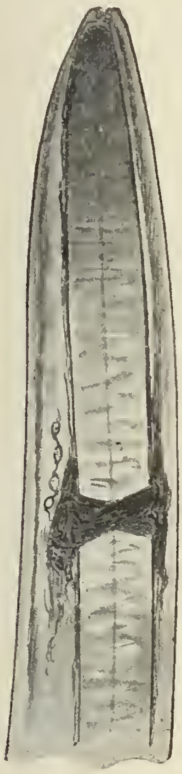


Fig. 10.

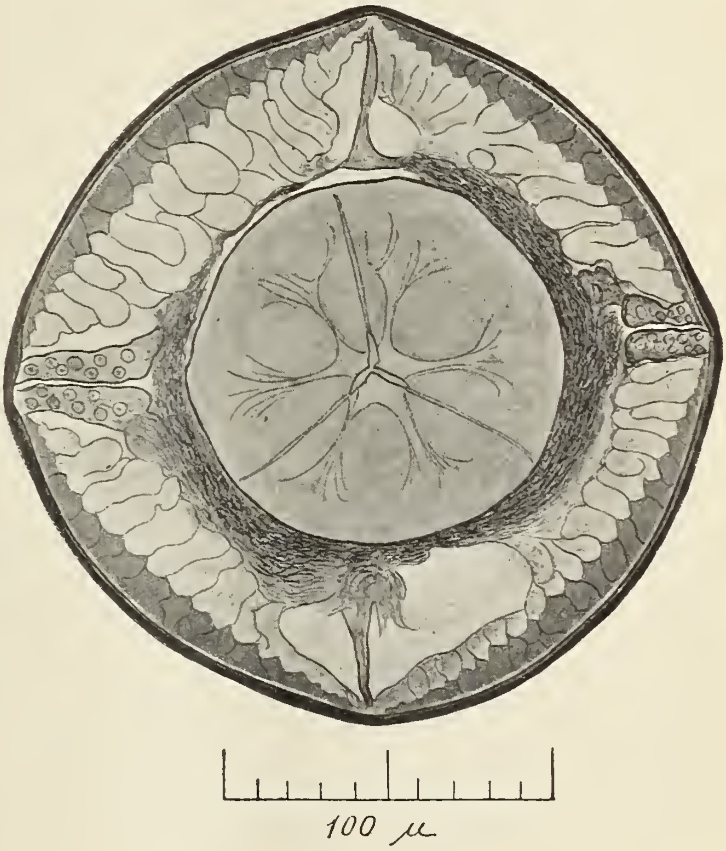


Fig. 11.

Fig. 10.—Enlarged view of the head, showing the central nervous system; the crossed condition of the fibers was quite evident in one specimen, but compared with other specimens this point in the drawing is somewhat exaggerated and diagrammatic.

Fig. 11.—Transverse section of head through region of the central nervous system. In addition to the characters described for fig. 5, note that instead of a bridge connecting the four longitudinal bands, there is a distinctly fibrillated structure which represents the central nervous system.

near the esophagus, but farther caudad it becomes somewhat flattened dorso-ventrally, so that its lateral diameter is about 308μ to a dorso-ventral diameter (closed lumen) of 202μ. The lumen is suppressed, or nearly so, and contains no food; the high, cylinder-epithelial cells are about 9μ broad; those near the median line are longer (in some cases attaining about 90μ) than those near the sides (which may decrease to 30μ); the nuclei of these cells are arranged near the distal end, namely away from the lumen, and measure about 6μ; the cells themselves contain numerous particles, apparently representing reserve food material;

the cuticle of the lumen is 6.6 to 8.8μ thick, and in the posterior portion of the midgut this cuticle may show a rod-like structure. In the anterior quadrangular portion of the midgut, fibres run from the submedian corners toward the body wall.

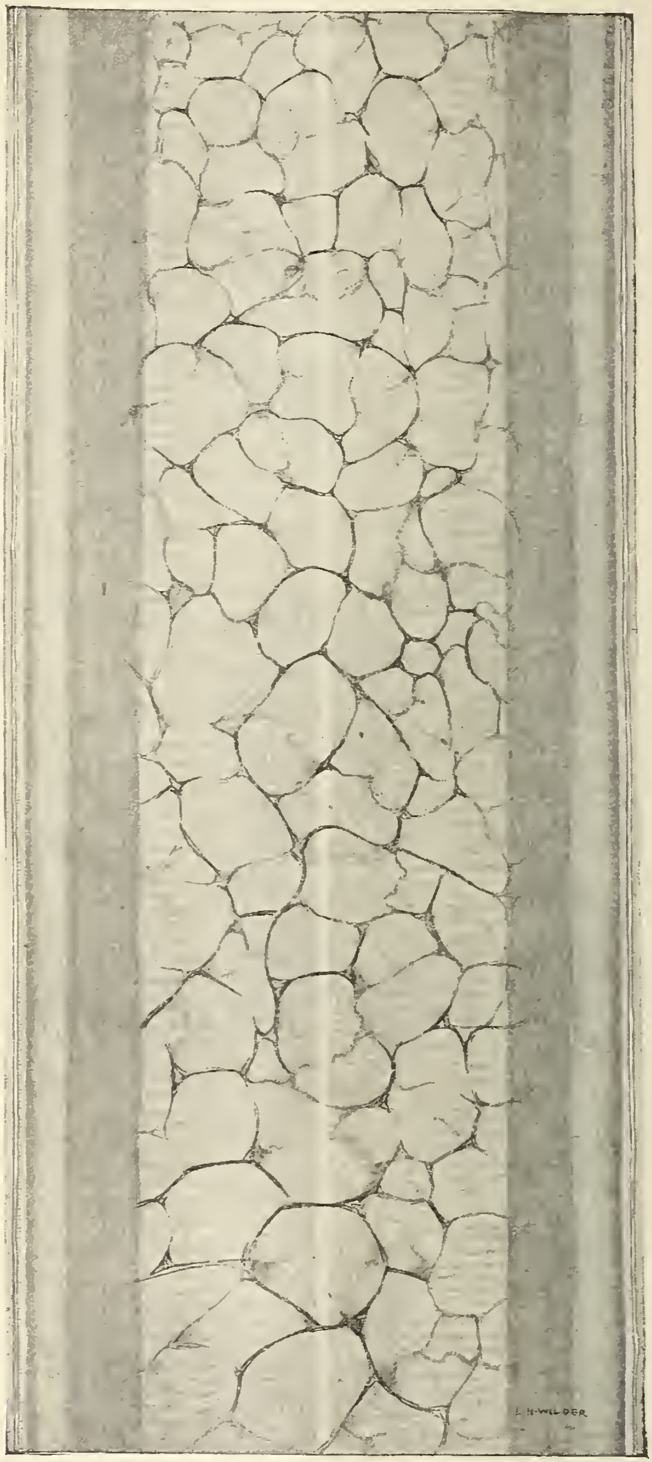


FIG. 12.—Enlarged view of a midgut portion of a worm cleared in glycerine, as seen dorsally or ventrally. Note the following characters: The clear line in the middle represents the median line or band; near this is seen a fine mesh work which represents the surface view of the intestinal epithelium, as seen upon deep focus; above is a much coarser network, which represents the surface view of the reticulum (compare fig. 6) between the muscular layer and the intestine; the broad band, occupying more than half the figure, is the intestine; laterally of this there is on each side a dark band, representing the excretory glands; lateral of these are the areas of the lateral bands, with their nuclei; then the subcuticula, and finally the cuticula.

Rectum.—The rectum (figs. 7-9) is about 200μ long. Several large nuclei are visible in this region, and certain cell boundaries can be dis-

tinguished, but the details were somewhat unsatisfactory, owing to the condition of the material.

NERVOUS SYSTEM.—The brain (figs. 10–11, 15) surrounds the esophagus at a plane corresponding rather closely to the excretory pore,

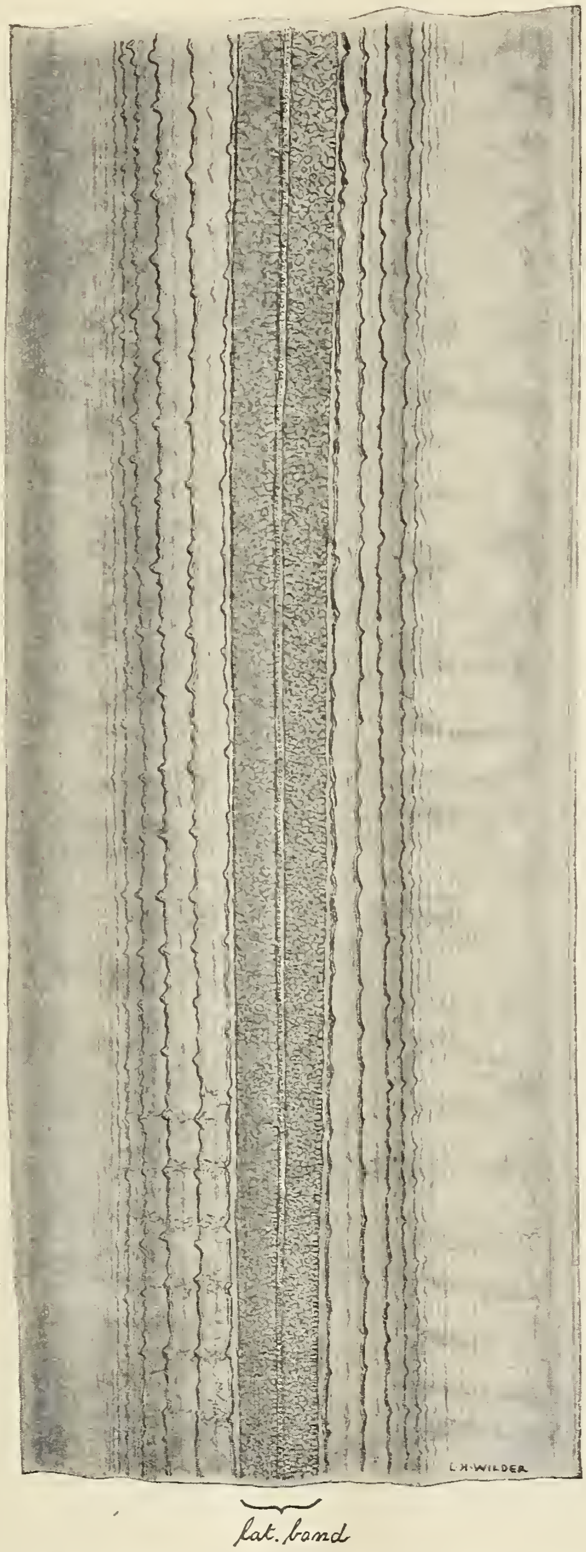


FIG. 13.—Enlarged lateral view of a midgut portion of a worm cleared in glycerine. Compare this with fig. 12, and notice the following details: The dark field in the middle is the lateral band (enlarged still further in fig. 14); this shows two parallel halves (dorsal and ventral), separated by a middle row of cells; the wavy, more or less parallel lines represent the somatic muscles; near the sides of the figure one obtains a lateral view of the large reticulum shown in fig. 12; on deep focus, this reticulum is, of course, much more distinct than can be shown in a view drawn in perspective.

namely, about 416μ from the anterior extremity. There is some slight variation in the different specimens, so that this measurement is some-

what diagrammatic and corresponds to an excretory pore 432μ from the cephalic end. A few cells, evidently ganglionic in nature, could be distinguished in the brain, but a detailed description of them would be difficult and rather unsatisfactory on the present material. Likewise a detailed description of the nerves would be likely to lead to errors of interpretation until fresh material can be found. It may be mentioned, however, that in one specimen in particular the fibers of the nerve ring seem to cross, as shown somewhat diagrammatically and in slightly exaggerated condition in fig. 10. At the submedian papillæ, and also in some other parts of the body, structures were observed which were strongly indicative of nerve elements, fibers, and ganglionic cells, but it is thought best not to describe them here and thus to avoid a danger of error of interpretation.

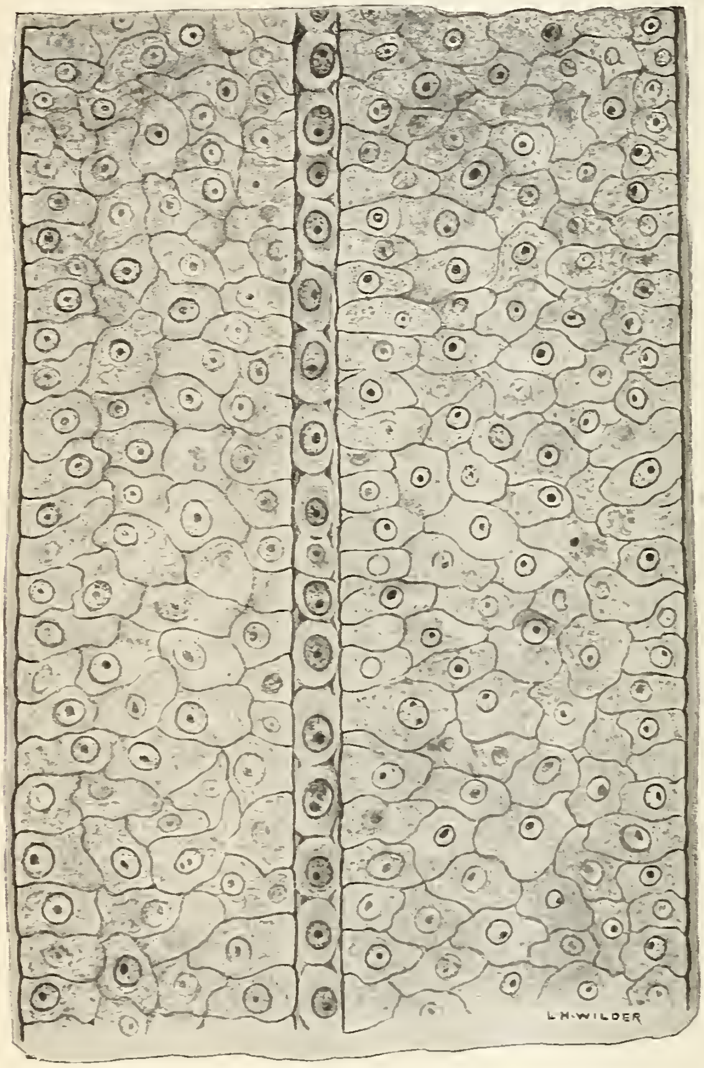


Fig. 14.—Very greatly enlarged lateral surface view of the lateral band of a specimen cleared in glycerine. Note the two halves (dorsal and ventral) of the band separated by a distinct line of cells; note also the nuclei and cells.

Muscular system.—On examination of mounted specimens cleared in glycerine a marked longitudinal striation is visible on certain focus. This striation, rather wavey in character in many places, represents the somatic muscles. On transverse section (figs. 6, 11–14) these muscles are seen to be arranged in four distinct quadrants, separated from each other by the four longitudinal lines. There are about 15 to 20 fibers per quadrant at about the cerebral plane, but in the equatorial plane there are many more—70 or more. These fibers are evidently quite long, but their length was not established. On cross section it is seen that the fibers in the submedian lines present the greatest radial diameter, while those nearer the longitudinal bands are smaller. The striation of the fibers is chiefly tangential to the worm, although occasionally a peripheral radial striation is noticed. The contractile substance of any given quadrant presents a notched or serrate appearance on its proximal border, and from the top of the

teeth of the serration centripetal fibers are noticed extending toward the intestinal tract. These centripetal fibers bound the protoplasmic processes of the muscle cells and form a mesh work which almost completely fills the body cavity and which gives a very striking picture as one views a mounted specimen cleared in glycerine. Because of the direction of the mesh work the dorsal and ventral views (fig. 12) of the worm, in respect to this mesh work, are entirely different from the lateral view (fig. 13). The superficial meshes are smaller than those which lie more deeply. The entire picture, as seen through the body wall, reminds one of adipose tissue. On transverse section, however, it is seen that fine fibers proceed from the apices of the serrate border of the muscular layer; these fibers extend in a general way toward the intestine, but in an irregular course. Approaching each other, they form small meshes near the muscle fibrillæ, with larger meshes toward the intestine. The smaller meshes near the muscle fibrillæ contain a finely granular mass; the larger meshes may be clear or nearly so. Nuclei may be observed here and there in the mesh work.

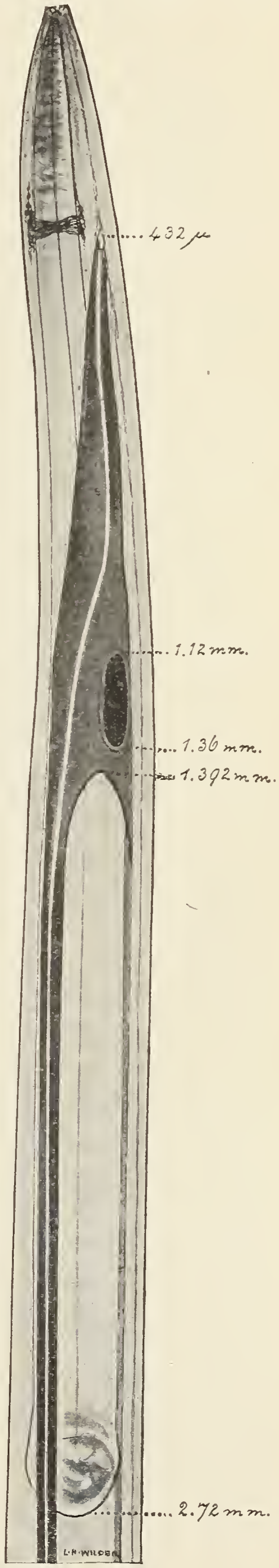


Fig. 15.—Enlarged ventro-lateral view of esophageal region of a specimen cleared in glycerine, very slightly diagrammatic. The esophagus is 2.72 mm. long; the brain is situated 0.416 mm. from the anterior end; the excretory pore is immediately ventro-caudad of the brain; from the pore a canal can be traced on the non-nucleated side of the bridge; the two excretory glands dip ventrally and unite ventrally of the esophagus; laterally and somewhat anterior of their point of union, an enormous nucleus (240μ long) is visible; no canal is drawn on the nucleated side of the bridge. The measurements on the right give the distance of the points in question from the head.

Longitudinal bands and subcuticula.—As stated in the foregoing, the lateral bands are much more highly developed than are the median bands; further, the lateral bands are in close relation to the excretory glands, so that the two together present an appearance which one is at first tempted to consider as indicating a common origin. Closer study, however, indicates a more distinct separation than at first seems probable.

Subcuticula.—The subcuticula is very thin, but in some sections, and even in some worms cleared in glycerine it appears quite distinct.

Median bands.—The median lines can be distinguished on most sec-

tions (figs. 5, 6, 11). In most sections the median bands are seen to extend as very narrow structures centripetally beyond the muscle layer and then to become broader. In the esophageal region, especially anterior of the brain, they are more distinct than in the midgut region, and immediately back of the mouth they are connected with the lateral bands to form a suspensory bridge around the esophagus (fig. 5).

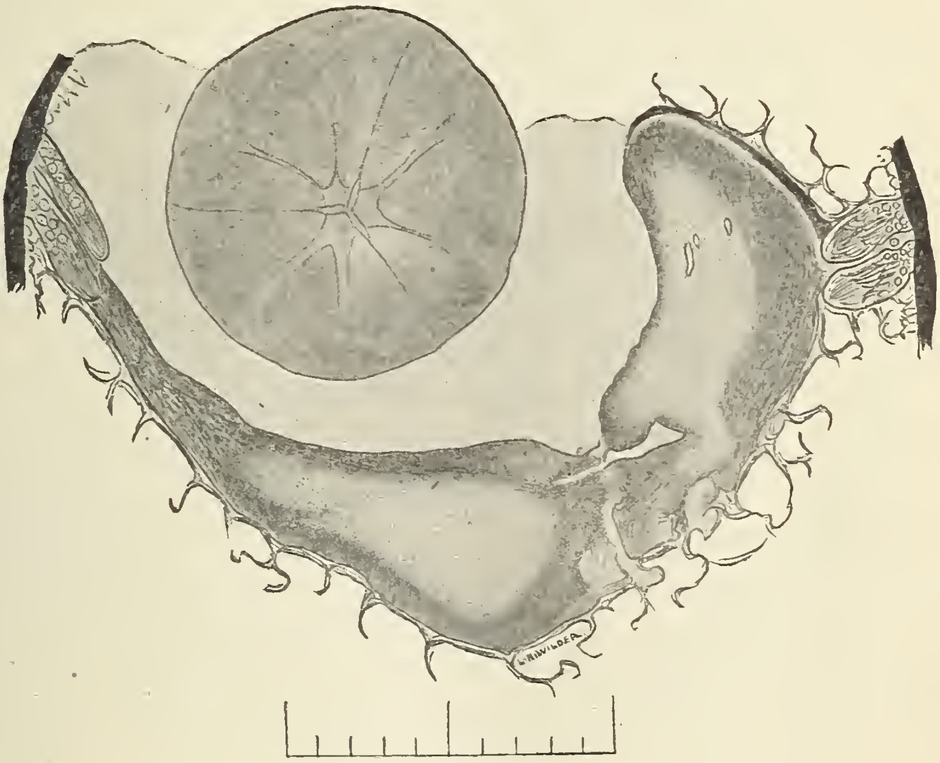
Lateral bands.—The lateral bands are much more complicated in structure than are the median bands. Very close to the mouth they are rather narrow (figs. 3, 5), extending centripetally, however, nearly to the esophagus. They may be more or less distinctly seen to be composed of two portions, one ventral, the other dorsal; each portion is supplied with distinct nuclei; farther caudad this division into a dorsal and a ventral portion is very apparent. Anteriorly, where the band is narrow, a lateral view of specimens cleared in glycerine shows two rows of nuclei directly under the cuticle—one row in the dorsal, the other in the ventral portion; on cross sections of this region not only are these two subcuticular nuclei visible, but in each portion a row of nuclei (fig. 5) is seen extending toward the esophagus.

Beside these two rows of nuclei, a third, at first less distinct, row of single subcuticular nuclei (figs. 3, 5) appears situated between the two more distinct rows and separating them; farther caudad, as will be shown below, this middle row becomes more distinct.

Centripetally of this middle row some sections seem to present a delicate but distinct longitudinal canal between the two (dorsal and ventral) halves of the lateral band. Whether this is an actual canal, as is indicated by the sections, or whether it is an artifact due to the material, may possibly be better left an open question for the present, for there are some sections in which the canal is not distinct, while in some sections which are torn the tear corresponds to this apparent canal. The sections in question can hardly form the basis for a strong argument against interpreting the structure in question as a canal, for the latter is a delicate structure, the lumen of which might easily be suppressed at some points, while any tear of the section would rather naturally occur at this point.

Farther caudad, for instance in the midgut region of the body, the lateral band presents a very striking appearance (figs. 13, 14). On examination of specimens cleared in glycerine the lateral view shows broadened dorsal and ventral halves, in which a distinct subcuticular cellular structure is evident; each cell presents a nucleus. While these nuclei are seen at almost any point, they appear more distinct and more regular near the margins of each half. The middle single row of cells becomes very distinct, separating the dorsal and the ventral halves of the band.

Sections (figs. 16 to 25) confirm the surface views, and show certain additional characters. There are two quite distinct thickenings of the cuticle at the lateral band, near the lateral line. The dorsal and the ventral halves of the lateral band are seen to vary considerably in transverse outline as sections are followed caudad, and the two halves are not symmetrical, one to the other. The nuclei are seen to be more massed and more numerous near the dorsal and ventral margins of each half than between these points; most of the nuclei are situated centrifugally (distally), but here and there nuclei are found some distance proximally (away from the cuticle); further, cellular prolonga-



100 μ

Fig. 16.

FIGS. 16–25.—Nine transverse sections of the lateral band and the excretory gland in different parts of the body, except that figs. 19 and 20 and figs. 21 and 22, represent the two glands on opposite sides of the same cross sections. Fig. 16 is anterior of the nucleus and shows a bladder-like widening (*ex. c.*), apparently belonging to the excretory canal. Fig. 17 is through the nucleus. Note the excretory canal (*ex. c.*) on the nonnucleated side. Dorsally of the nucleus is a thick-walled canal-like structure. The nucleus is somewhat contracted from the nuclear membrane. Fig. 18 is a section caudad of the point of union of the bridge. Figs. 19–20 show the two lateral bands and two glands from one section. Note their asymmetry. Figs. 21–22 show the two lateral bands and glands further caudad. Fig. 23 shows a section in which the gland has reduced in cross section and exhibits a reticular structure. Fig. 24 shows a section still farther caudad. Fig. 25 shows a section near the caudal end of the gland. The latter is very small.

tions are seen to extend centripetally, toward the proximal margin of the lateral band; in some cases these cells were followed nearly or quite to the proximal margin; in some sections there appeared to be a decidedly distinct differentiation in the proximal (centripetal) portion,

indicative of a lack of distinct cellular structure; whether this differentiation was an artifact, and more apparent than real, due to the condition of the material, may better be left for decision when fresh material can be examined. The dorsal, ventral, and proximal margins of each half of the band present a condensed appearance which in not a few sections is indicative of a distinct membrane.

Toward the lateral line, corresponding to a frontal plane of the worm, the dorsal and ventral halves of the lateral bands are distinctly separated. This separation is due primarily to the single, middle row of cells mentioned above. The nuclei of these cells can be very distinctly seen both on surface views and on section, but it is more diffi-

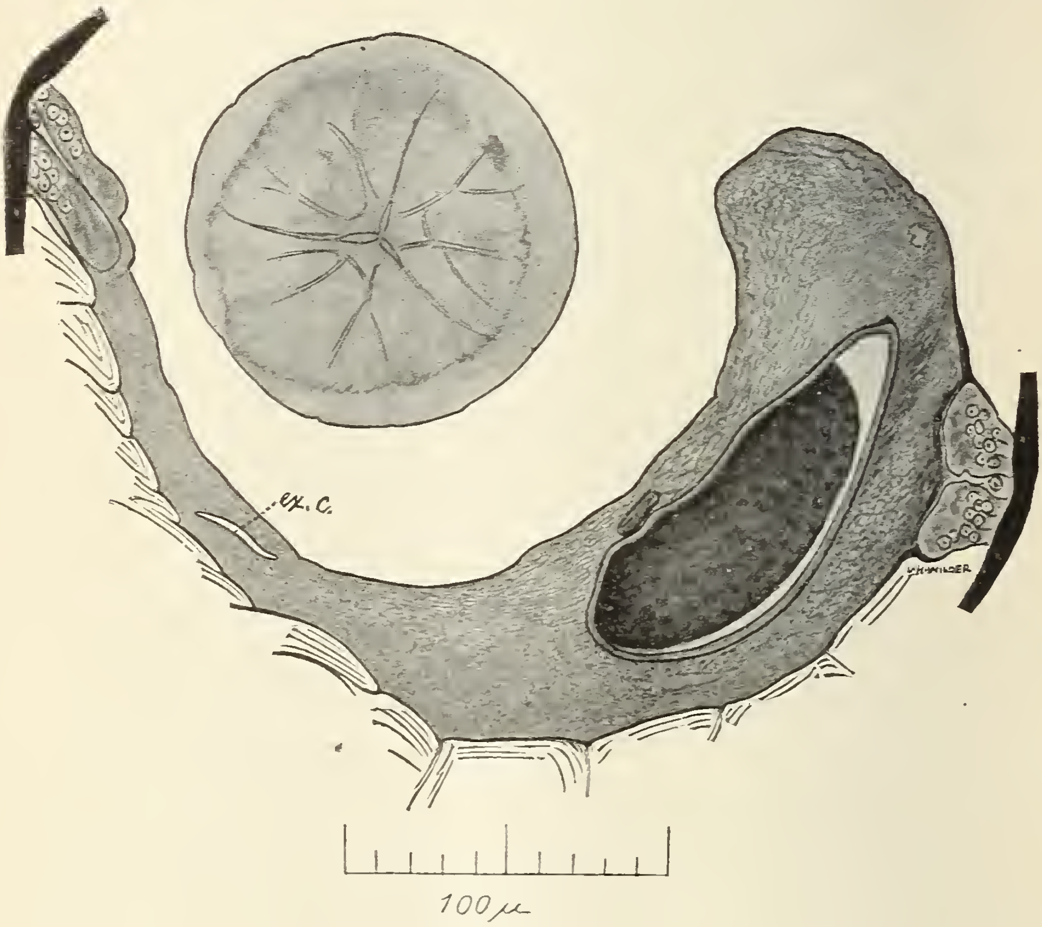


Fig. 17.

cult to trace the centripetal portion of the cells themselves. In some sections the cells could be quite distinctly followed to the proximal borders of the two halves of the band, namely to the point at which the gland (to be described below) meets the marginal point between the two halves of the band. The picture obtained was strongly indicative of an interpretation that the middle row of cells in question acted as a connective element between the gland and the subcuticula. Such an intrepretation was not confirmed, however, by some of the sections, for the cell could not be traced to the proximal margin, and the space not occupied by the cell appeared not unlike a canal; the possibility is by

no means excluded that this canal-like appearance was an artifact; in fact, certain sections strongly indicated that it was. In still other sections, the middle cell was rather short, but a process from the large gland could be followed centrifugally between the dorsal and ventral halves of the band, nearly or quite to the middle cell.

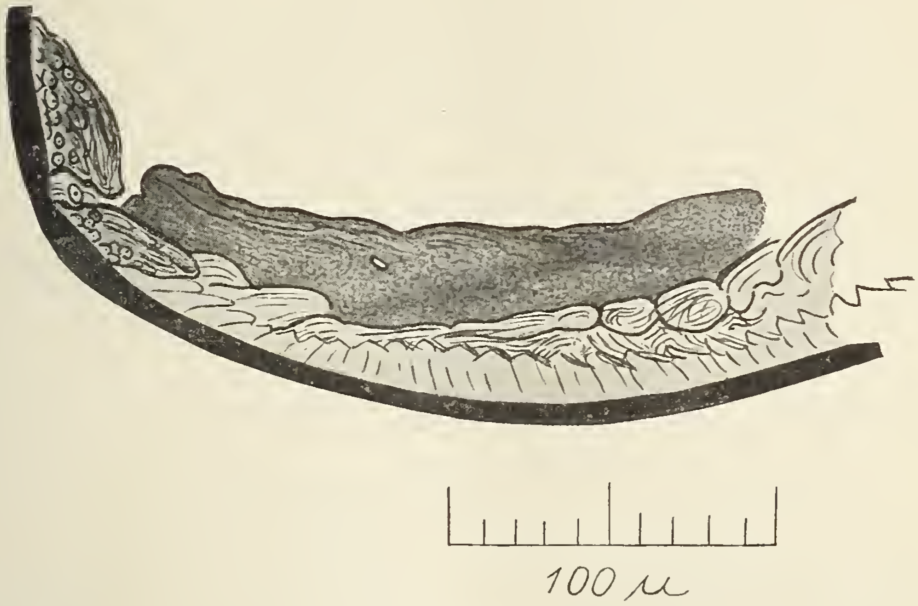


Fig. 18.

The determination of the existing conditions must be left for study of fresh material, notwithstanding a strong indication on some surface views of the existence of a longitudinal canal with a lumen of about 4 to 6 μ in diameter.

Excretory system.—The excretory system is very striking, but only a part of it can be interpreted at present.

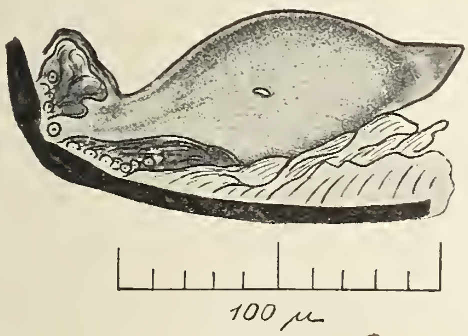


Fig. 19.

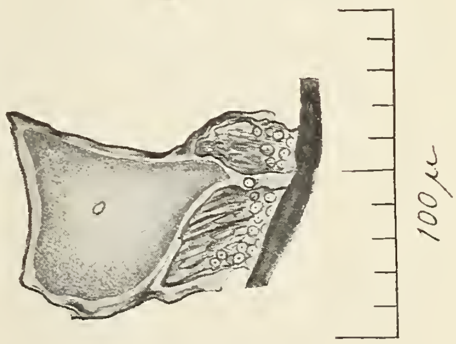


Fig. 20.

On surface views of worms cleared in glycerine a large, longitudinal ridge, of somewhat sinuous outline longitudinally, is seen on each side of the body, in close relation to the lateral bands. On transverse sections several prominent characters of this ridge are distinctly visible. In the first place it is seen that in any given section the transverse outline of the two ridges may be entirely different (compare fig. 19

with fig. 20, and fig. 21 with fig. 22); this fact is easily explained by the sinuous character noticed on surface views. Independent of this variation between the two ridges of any given transverse section, there is a marked difference in the transverse outline of the gland in different parts of the body. This outline is to some extent correlated with the transverse outline of the lateral bands, for, in general, when the bands are low radially the gland is likely to be large, while when the gland is small the bands are likely to be larger radially. The gland may be followed into the posterior portion of the body, where it becomes very small; toward the esophageal portion of the body, it becomes larger and more prominent.

Another point visible on transverse section is the presence of a distinct canal in about the center (axial line) of each gland; although some sections were found in which this canal was not distinguishable, it was distinct in so many sections that its existence can hardly be questioned.

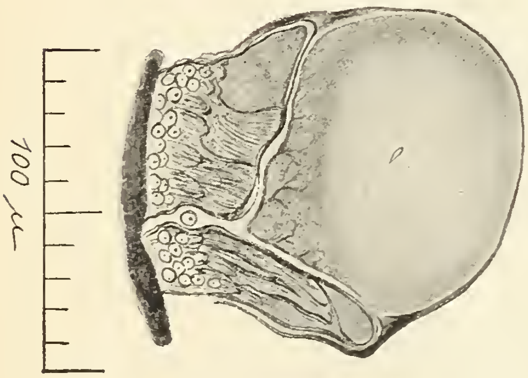


Fig. 21.

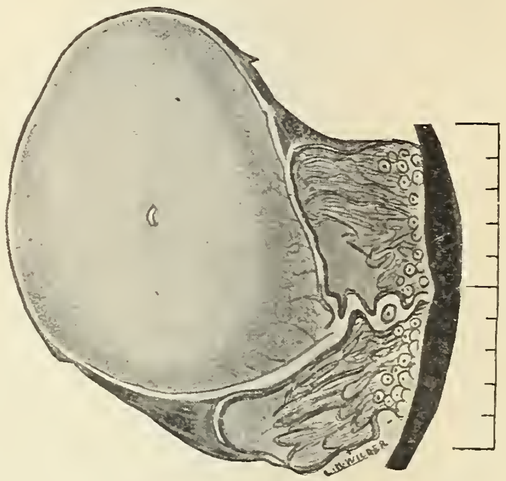


Fig. 22.

In some sections, the gland appeared granular, in others it was more distinctly reticulate in appearance.

Surface views of the middle (equatorial) esophageal region (fig. 15) show that the two longitudinal glandular ridges dip ventrally and unite to form a bridge; the united structure can then be traced cephalad nearly or quite to the excretory pore; one canal also is seen to dip ventrally and can be traced to the excretory pore; the natural expectation is that the two canals (one from each side) unite before reaching the pore; on surface views the point of union was not recognized. On sections the excretory pore was confirmed; almost directly dorsally of it were at least two (possibly several) cells, each with a distinct nucleus; tracing the excretory canal caudad it is seen to possess for a short distance a rather thick cuticle; suddenly the wall becomes thin and the canal *seems* to broaden into a larger cavity resembling a bladder (fig. 16); several of the following sections are unsatisfactory, but the canal can be traced on the nonnucleated side (see below) of the bridge

until it reaches the vicinity of the lateral bands, corresponding to what was observed in two worms cleared in glycerine (fig. 15). On the nucleated side of the bridge the study was less satisfactory, but dorsad of the nucleus a thick walled canal-like structure was observed in several sections (fig. 17).

On surface views a large, distinct, and rather remarkable nucleus is also visible; this is situated slightly cephalad of the point of union of the glands and appears to be unilateral; at least, in no specimen, either on surface view or in section, could two such nuclei be distinguished. This fact, that only one nucleus could be found, is strongly indicative of an interpretation that the two glands together represent in reality only one cell. As the nucleus found was very distinct, it is difficult to assume that the absence of a second nucleus was due to the condition of the material.

This nucleus varies slightly in shape, but, in general, it is much longer than broad; it may attain a measurement of 296 to 316μ long (parallel with longitudinal axis of body) by 90 to 132μ broad (trans-

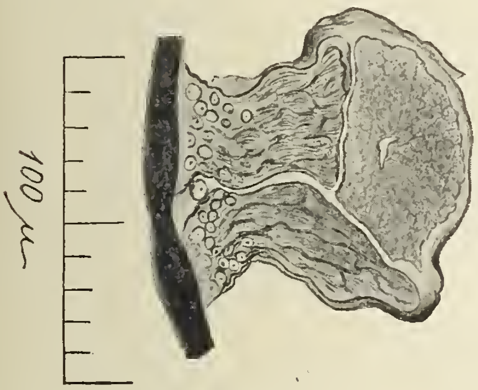


Fig. 23.

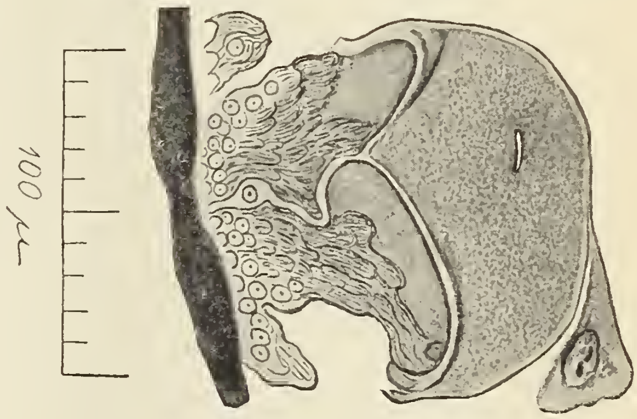


Fig. 24.

verse to longitudinal axis of body). Both in mounts of the entire worm and in sections, the nucleus presents a thick nuclear membrane and a content of exceedingly large granules. Its appearance is very suggestive of the large nuclei of the cephalic glands of *Agchylostoma duodenale* (see especially Looss, 1905, figs. 5 and 38).

From the foregoing description it will be seen that the glandular structures do not correspond closely, so far as could be observed, with the conditions described by Looss (1905) for *Agchylostoma duodenale.* While recalling the unsatisfactory condition of the material, it is seen that no true distinct systems of cephalic and cervical glands have been observed, and that what would seem to correspond to the head glands of *Agchylostoma duodenale*, judged from their position in respect to the lateral bands, and from the large nucleus, appear to discharge through the excretory pore; further, that the two sides of the animal are not symmetrical in respect to these structures. Further study is, of course, advisable on material in better condition.

The ridge does not necessarily extend directly at right angles to the median line of the lateral bands, but may fall toward the median surface lines of the body; thus, in an examination of a worm mounted whole, one may focus superficially upon the margins of the true lateral band and then more deeply upon the displaced margin of this ridge; such change of focus gives an impression that the lateral band is broader than it really is.

A *longitudinal canal* may be seen in transverse sections of this ridge. This canal can be traced on sections caudad practically to the caudal end of the ridge; in tracing it cephalad, some sections were found in which the canal could not be distinguished with certainty, but in the majority of the sections it was visible.

Fig. 25.

Even from this rather incomplete description, it is seen that the ridge is not an integral part of the proliferation of the subcuticula which forms the lateral bands *s. str.*, but rather an organ of glandular appearance, reminding the observer of the so-called cephalic gland, described in certain nematodes.

GENITAL ORGANS.—In no specimen were structures found which could be positively interpreted as representing genital organs. One would naturally assume that in an animal of this size there must be such organs present in at least an early stage of development. Probably they are present, although they could not be recognized.

BODY CAVITY.—The body cavity is almost completely occupied by the intestine, lateral ridges, and the mesh work extending inward from the muscular layer. In addition to these structures a considerable amount of more or less coarsely granular material was found; in at least one instance a granular structure (?? primordium of the genital organs) was found unilaterally, close to the lateral band near the posterior end of the chyle intestine.

THE ZOOLOGICAL CHARACTERS OF THE ROUNDWORM GENUS FILARIA MUELLER, 1787, WITH A LIST OF THE THREAD WORMS REPORTED FOR MAN.

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(Figs. 26–34.)

Of the zoological names used by physicians, the generic name *Filaria* is one of those most commonly quoted. As used both by zoologists and by physicians, this name has been made to act as a generic catch-all for slender roundworms which could not be definitely determined.

Recently an apparently new species of roundworm (*Agamofilaria georgiana*) from a superficial sore on the ankle of a negress was sent to me by Dr. St. J. B. Graham, of Savannah, Ga., for determination, and upon trying to classify it I found that it could easily be placed in the genus *Filaria* as generally understood. From a systematic viewpoint this was unsatisfactory, and this fact led me to trace the history of the genus *Filaria*. The results obtained have a bearing upon the parasites of man and part of them are herewith published in the hope of aiding to clear up this group of parasites, so little understood zoologically despite the enormous amount of literature which has appeared upon the subject.

The genus *Filaria* was established in 1787, by Mueller. In the original publication Mueller did not mention any specific names, but he referred to a number of parasitic worms in various animals, and comparing his bibliographic references with Gmelin, 1790a, it is clear that he classified the following worms in his new genus:

A. In mammals:

1. *Filaria leonis* Gmelin, 1790a; this form has been viewed since 1809 as a species inquirenda.
2. *F. leporis* Gmelin, 1790a; this form has been viewed since 1809 as a species inquirenda.
3. *F. martis* Gmelin, 1790a; of the three original filariæ of mammals, this species alone has been found and described on several occasions since 1790. It apparently contained two species. Of these, *Filaria mustelarum* [*pulmonalis*] has been separated as the type of *Filaroides*, and the remaining form has been renamed *Filaria mustelarum subcutanea* 1819, *F. quadrispina* 1851, and *F. perforans* 1858.

B. In birds:

4. *F. gallinæ* Gmelin, 1790; eliminated from *Filaria* since 1803.

5. *F. falconis* Gmelin, 1790a; considered identical with either *F. foveolata* 1858, or with *F. nodispina* 1858.

6. *F. ciconiæ* Gmelin, 1790a; incompletely known, possibly identical with *Dicheilonema labiatum.*

C. In insects: Eight species belong here, but it is clear that Mueller intended to separate them from *Filaria.*

Of the species mentioned above, it is clear that either *martis* or *falconis* should be taken as type of *Filaria*, and as circumstances distinctly favor *martis*, this was designated type by Stiles & Hassall (1905, 106). Accordingly, *Filaria martis* must be studied in order to determine what the genus *Filaria* represents.

Filaria martis was originally described, but not named, by Redi. It occurs in the pine marten (*Mustela martes*) and several other animals, in Europe. The form which occurs in Europe in the pine marten should be taken as the standard of reference. This worm has been found by several authors; it has been renamed several times, but, unfortunately, its anatomy is not very well studied. No specimen is at my disposal at present, but from the accessible literature it may be seen that the parasite presents the following synonymy, bibliography, and zoological characters:

FILARIA MARTIS Gmelin, 1790.

[Figs. 26 to 34.]

1790: *Filaria martis* Gmelin, 1790a, 3040 (ex Redi).—Bosc, 1802a, v. 2, 48; 1830a, v. 2, 59.—Diesing, 1851a, 272 (syn. of *F. quadrispina*).—Molin, 1858, 387 (syn.

Fig. 26.

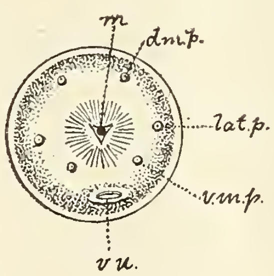

Fig. 27.

Fig. 28.

Fig. 29.

Fig. 26.—Anterior end of female *Filaria martis*, from *Mustela martes*, Italy; *a*, mouth. Enlarged. (After Alessandrini, 1838, pl. 1, fig. 1.)

Fig. 27.—View of anterior end, en face: *m*, Mouth; *dm. p.*, dorso-submedian papilla; *lat. p.*, lateral papilla; *vm. p.*, ventro-submedian papilla; *vu.*, vulva. Enlarged. (After Schneider, 1866a, pl. 5, fig. 9.)

Fig. 28.—Tail of female. Enlarged. (After Alessandrini, 1838, pl. 1, fig. 4.)

Fig. 29.—Tail of male, showing spiral and spicule. (After Alessandrini, 1838, pl. 1, fig. 2.)

of *F. perforans*); 1858, 167 (syn. of *F. perforans*).—Ransom, 1904, 31.—Rudolphi, 1809a, 69 (renamed *F. mustelarum*); 1810a, 379.—Stiles & Hassall, 1905, 106 (type of *Filaria*).—Stossich, 1897, 33 (syn. of *F. quadrispina* Dies-

ing); 1898, 95 (syn. of *F. quadrispina* Diesing).—Zeder, 1803a, 38 (ex Redi; sub cute, *Mustela martes*).

1794: ?*Filaria medinensis* Rosa, 1794, 2 (not accessible to me).—Diesing, 1851a, 272 (as doubtful syn. of *F. quadrispina* Diesing).—Molin, 1858, 387 (as doubtful syn. of *F. perforans*); 1858, 164, 167 (in *Mustela foina*, sub cute; as syn. of *F. perforans*).

1809: *Filaraia mustelarum* Rudolphi, 1809a, 69, misprint for *Filaria mustelarum*, q. v.

1809: *Filaria mustelarum* Rudolphi, 1809a, 69 (includes Redi, 24, 25, pl. 9, fig. 3, vers. p. 34; and *F. martis* Gmelin, 1790a, 3040; infra pellem et inter musculos *Mustelæ foinæ, martis,* et *putorii*, Redi); 1810a, 379–380.—Alessandrini, "1843, 530."—Bosc, 1830a, v. 2, 59.—Diesing, 1851a, 272 (syn. of *F. quadrispina*); 1857a, 18 (13).—[Dujardin, 1845a, 47].—Molin, 1858, 387 (syn. of *Filaria perforans*); 1858, 166, 167.

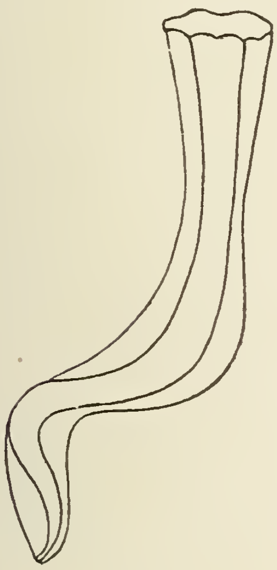

Fig. 30.

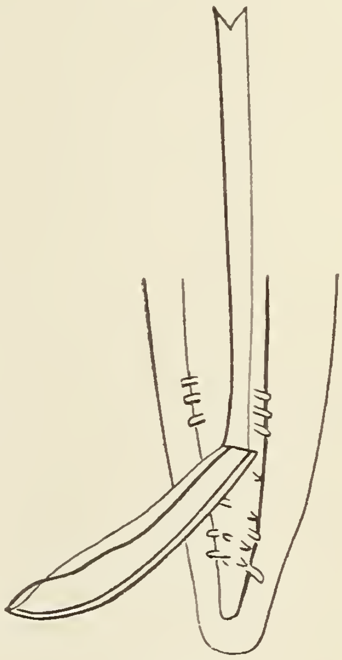

Fig. 31.

Fig. 30.—Tail of male, flattened to show the alæ. Enlarged. (After Alessandrini, 1838, pl. 1, fig. 3.)
Fig. 31.—Tail of male, ventral view, showing alæ, spicules, and papillæ. Enlarged. (After Schneider, 1866a, 86.)

1819: *Filaria mustelarum subcutanea* Rudolphi, 1819a, 7, 216 (*F. mustelarum* Rudolphi, 1809, renamed; sub cute *Mustelarum foinæ, martis,* et *putorii*).—Alessandrini, 1838, 1–17, pl. 1, figs. 1–12 (in *Mustela foina*).

1846: *Filaria mustelæ foinæ* Creplin, 1846b, 161.

1850: *Filaria quadrispina* Diesing, 1851a, 271–272 (includes Redi, 24, 25, pl. 9, 3, vers. 34; *F. martis* Gmelin, 1790a; *F. medinensis?* Rosa, 1794, 2; *F. mustelarum* Rudolphi, 1809a; in *Mustela foina, M. putorii, M. martes;* sub cute et inter musculos, Europe).—Molin, 1858, 387 (syn. of *F. perforans*); 1858, 165, 166, 167, 168 (syn. of *F. perforans*).—Parona, 1896, 6.—Schneider, 1866a, 85–86, 1 fig., pl. 5, fig. 9 (in *Mustela martes* and *Hystrix cristata*, under the skin).—Setti, 1897, 48–49 (in *Mellivora capensis;* Ghinda).—Stossich, 1890, 11 (in *Mustela foina*); 1890, 56; 1893, 3; 1896, 122 (4), fig. 17); 1897, 32–33; 1898, 95 (in *Mustela foina;* at Trieste, Cittanova); 1902, 11 (in *Mellivora capensis;* Ghinda (Eritrea), N. E. Africa).

1858: *Filaria perforans* Molin, 1858, 387 (includes Redi, 24, 25, pl. 9, 3, vers. 34; *F. martis* Gmelin, 1790a; *F. medinensis?* Rosa, 1794; *F. mustelarum* Rudolphi, 1809a; *F. quadrispina* Diesing, 1851a; *F. mustelæ barbæ* M. C. V.; in *Mustela foina, M. putorius, M. martes*, sub cute inter musculos; and *Gulo barbatus*, in

cavo thorac., Ypanema); 1858, 155 (in *Mustela foina;* Padua); 1858, 161–170; 1861, 316–318, pl. 14, figs. 7–8 (supposed young stage, encysted).—Blanchard, 1890a, 3.—Diesing, 1861a, 700; 1861c, 280.—Grassi, 1887g, 622.—Parona, 1887, 495 (in *Mustela foina;* Genova Zool. Mus.); 1894, 240; 1896, 6 (in *M. foina*).—Setti, 1897, 48 (syn. of *F. quadrispina* Diesing).—Stossich, 1898, 95 (syn. of *F. quadrispina* Diesing).

1858: ? *Filaria mustelæ barbaræ* M. C. V. Collect. Brasil. in Molin, 1858, 387 (syn. of *F. perforans*).

1858: ? *Filaria mustela barbata* Molin, 1858, 168, for *F. mustelæ barbatæ.*

1894: "*Filaria subcutanea?*" in Parona, 1894, 240.

Specific diagnosis.—*Filaria* (p. 36): Body white, slender, filiform, very long, subequal; anterior extremity attenuated, obtuse; posterior extremity very attenuated, more so than head. Cuticle without a trace of transverse striation (Alessandrini, 1838). Mouth small, round, unarmed, surrounded by 4 submedian noduliform papillæ; in the female the ventro-submedian papillæ are somewhat nearer the mouth than are the dorsal (Schneider); in the male the papillæ are somewhat displaced (Stossich).

Male: 73 mm. long (2 to 3″ by $\frac{1}{8}$ to $\frac{1}{4}$‴). Caudal extremity forms a spiral; provided with broad cuticular alæ (bursa) which meet terminally; with 9 pairs of ventral filiform papillæ, 3 pairs preanal, 6 pairs postanal: 1 and 2, 3 and 4 close together; 5 and 6 near the median line (Schneider). Spicules unequal: the larger spicule in form of a tube, with broad, transversely striated alæ; the shorter spicule conical.

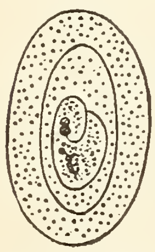

Fig. 32.—Egg. Enlarged. (After Stossich, 1896.)

Female:[a] 190 mm. long (4 to 7″ by $\frac{1}{4}$ to $\frac{1}{2}$‴). Caudal extremity acuminate, somewhat curved ventrad; "anus at apex" (Alessandrini). Vulva anterior, very close to the mouth, almost terminal. Viviparous (Molin); ovoviviparous (Alessandrini).

Eggs: Very numerous, small, elliptical, with very thick shell and covered with very minute granulations (Stossich).

Habitat.—Under the skin, and elsewhere, of various European Carnivora: Pine Marten (*Mustela martes* Linnæus); Beech Marten, Stone Marten, or White-breasted Marten (*Mustela foina*); Common Polecat (*Putorius putorius*); Common Porcupine (*Histrix cristata*); the Ratel (*Mellivora capensis*=*M. ratel*). Also reported for one American host: Tayra (*Gulo barbatus* Desm.=*Mustela barbara* Linnæus=*Galictis barbara*=*Galora barbàra*) [legitimate doubts may arise regarding the specific identity of the Brazilian parasite[b] with the European form].

Geographic distribution.—Italy, Austria, Eritrea (Africa), and ? Brazil.

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[a] In referring to filariæ "des martres et des putois," Dujardin (1845a, 48) says that a filaria sent from Vienna to the Paris Museum in 1816, and labeled as having been found under the skin of a marten is a female, 170 mm. long, by 0.4 mm. in diameter, with a head 0.10 mm. in diameter, obliquely truncate, and with a very small round mouth near the margin; its tail is equally obtuse, 0.07 mm. broad. The eggs, with which this helminth is filled, are elliptical, nearly round, 42 μ long, covered with a caducous granular layer, and show an enrolled embryo. "It is very probable from these characters that it should be placed in another genus."

[b] Molin (1858, 168) examined a female taken by Natterer in Brazil from the thoracic cavity of *Gulo barbatus*, and states: "Questo corrispondeva esattamente alla descrizione che ho dato delle Filarie sottocutanee delle martore; soltanto la sua estremità caudale era molto ottusa. Esso misurava 6″ in lunghezza, e $\frac{1}{2}$m [=‴] in larghezza."

Molin (1861, 316–318, pl. 14, figs. 7–8) describes a young encysted worm which he interprets as the young stage of *F. perforans.* This interpretation is, as Molin indicates, subject to confirmation. His account is here given in the original, as the work in which it was published is not generally accessible:

HABITACULUM.—*Mustela putorius:* sub cute et in tela conjunctiva intermusculari, omni anni tempore. *M. foina:* sub cute et in tela conjunctiva intermusculari, omni anni tempore; inter pericardium et cor, in corde sub endocardio, in cavo thoracis et abdominis, et sub cute, Decembre, Patavii (Molin).

Osservazione 1. Ad ogni epoca dell' anno rinvenni numerosi esemplari tanto maschi che femine del suddetto verme sotto la cute e fra i muscoli delle puzzole e delle faine, specialmente presso alle scapule ed al capo del femore.

Al 31 di Decembre 1857 ricevetti 2 grandi faine. In una di queste rinvenni una filaria perfettamente sviluppata ravvolta intorno agli atrii del cuore sotto il pericardio, ma nessun verme sotto la cute. Nell' altra invece ritrovai parecchie filarie sotto la cute e due piccole sopra il peritoneo nella regione delle coste spurie, le quali avevano di già perforato la cavità addominale e passavano dall' altra parte per annidarsi sotto la cute. Nella prima faina però oltre alla filaria intorno al cuore rinvenni l' omento e la faccia esterna dello stomaco tempestati da piccole vescichette del diametro di circa 0.001 ciascuna delle quali contevena, oltre un fluido nel quale nuotavano dei corpuscoli simili a cellule, un vermetto attortigliato della lunghezza di circa 0.003. Già per lo innanzi avevo riscontrato due volte sul peritoneo delle faine due o tre piccole vescichette con entrovi lo stesso verme. Nella faina nella quale trovai vescichette sull' omento, ne rinvenni una ma molto più piccola nella camera destra del cuore sotto il pericardio. Essendo esse abbastanza trasparenti, ne posi alcune sotto al microscopio dopo d' averle un momento compresse. Ed osservando attentamente ho potuto assicurarmi che il verme contenutovi era vivo e si moveva.

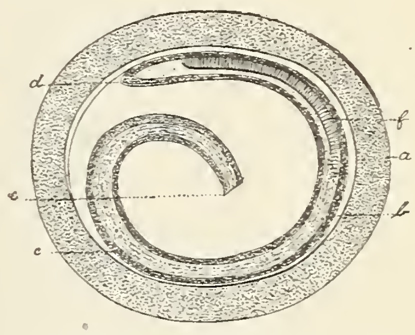

FIG. 33.—Supposed young, encysted stage of *F. martis: a,* Transparent cyst; *b,* internal membrane; *c,* coiled worm; *d,* head; *e,* tail; *f,* stomach. Enlarged. (After Molin, 1861, pl. 14, fig. 7.)

Osservazione 2. Fatte scoppiare le vescichette mediante una compressione più forte, ne sortì il verme, il quale sotto un forte ingrandinmento mostrava il corpo pressochè cilindrico, un momento attenuato all' innanzi e obbliquamente tronco non che acuminato all' estremità caudale. Egli aveva all' estremità anteriore la apertura della bocca circondata da tre piccolissime papille, e il margine inciso ad angolo in un punto. Dall' apertura della bocca partiva la faringe corta ed angusta la quale si dilatava nello stomaco circa quattro volte più largo e lungo un terzo del corpo. Dallo stomaco fino all' ano, collocato in fianco un poco all' innanzi dell' apice caudale, estendevasi il budello un po' più angusto. Dallato del budello potei distinguere un altro tubo molto esile, il quale ricorda gli organi genitali interni della *Filaria perforans.* Lo stomaco era troppo opaco per poterne studiare l' istologia; ma tanto il budello che l' altro tubulo vicino sembravano composti di piccole cellule poligonali collocate a musaico una presso l' altra. Da questa circostanza credetti poter conchiudere che questi vermi erano ancora in uno stadio remoto di sviluppo. Confrontati questi vermi colla *Filaria perforans* sembravano identici, meno le papille intorno alla bocca. Forse questi saranno organi, i quali vanno perduti, ovvero si modificano coll' incremento dell' animale. Dal complesso di queste osservazioni credo però che facilmente risulti che la prole delle filarie entrano nelle cavità del

corpo, che quà si sviluppano i giovani vermi, i quali arrivati a certa grandezza perforano dall' interno all' esterno le pareti del corpo per annidarsi sotto la cute. Quali sieno le loro peregrinaziono ulteriori, come arrivino a depositare le uova nella cavità addominale, sono quesiti impertanti bensì ma tali che soltanto qualche osservazione accidentalmente fortunata sarà in istato di sciogliere. Io ho creduto necessario il pubblicare quetsi fatti affinchè possano servire di traccia a qualche altro investigatore.

Osservazione 3. Ho voluto dare un' imagine tanto del verme nella vescichetta che isolato.

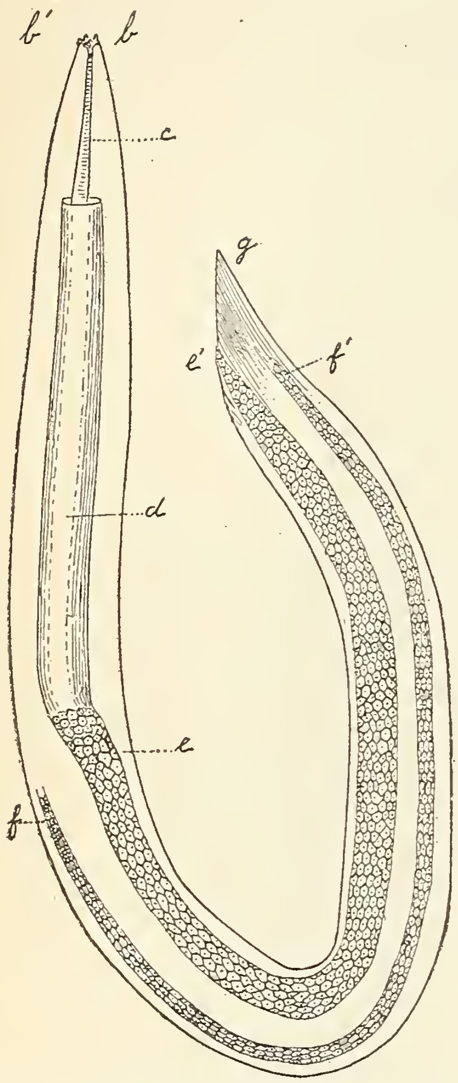

Fig. 34.—Worm freed from its cyts: *a*, Mouth; *b*, *b'*, papillæ; *c*, "pharynx;" *d*, "stomach;" *e*, *e'*, intestine, with polygonal cells; *f*, *f'*, genital organs; *g*, tail. Greatly enlarged. (After Molin, 1861, pl. 14, fig. 8, reduced to two-thirds of original figure.)

Any generic diagnosis written for the genus *Filaria* should contain the major characters given above (p. 34) for *Filaria martis*. This species, which does not appear to be rare, should be carefully restudied for other characters; some characters of striking nature are almost positively absent from *F. martis*, otherwise authors would doubtless have mentioned them. While it is impossible to write a detailed diagnosis for *Filaria* until the type species is restudied, we are now in a position to determine some of its most important characters; and these we may safely take as minimum characters for a type subgenus *Filaria* (*Filaria*), even if not for the genus *Filaria*.

Subgenus FILARIA Mueller, 1787.

1787: *Filaria* Mueller, 1787, 64–67 (type by elimination, *F. martis* Gmelin, 1790, in subcutaneous, tissue of *Mustela martes* of Italy); from *filum*, a thread.
1809: *Filaraia* Rudolphi, 1809a, 69, misprint
1840: *Filaire* Lee, 1840a, 283, misprint.
1877: ? *Wuchereria* Silva Araujo, 1877, Nov., 492, 504, mentioned as *Wuchereria filaria* possibly a lapsus for *Filaria wuchereria*.
1877: *Filariu* Magalhães, in Silva Lima, 1877, Dec., 544, misprint.
1884: *Filoria* Calmette, 1884a, 459, misprint.
1904: *Falaria* Leidy, 1904a, 190, misprint.

Subgeneric diagnosis.—*Filaria:* Very long, filiform worms. Cuticle unstriated (Alessandrini) and evidently without bosses. Mouth small, round, unarmed, terminal, without lips.

Male: Shorter than the female; tail forms a spiral, and is provided with lateral cuticular alæ and with both preanal and postanal, filiform, papillæ, spicules unequal.

Female: Vulva anterior, very close to the mouth.

Type-species.—*Filaria martis* Gmelin, 1790.

While it is to be regretted that the present anatomical knowledge does not permit a more complete diagnosis, the characters given above furnish us a certain amount of valuable information in regard to the necessity of excluding from the typical *Filaria* certain other worms, usually classified as members of this genus.

A large number of different species of *Filaria* have been described. Of these, the following species have been taken as types of distinct genera:

æthiopica Valenciennes, 1856, see *medinensis*.
anthuris Rudolphi, 1809a (*Acuaria* Bremser, 1811; *Anthuris* Rudolphi, 1819; *Spiroptera* Rudolphi, 1819; *Dispharagus* Dujardin, 1845).
bourgii see *loa*.
caudispina Molin, 1858 (probably type of *Dipetalonema* 1861).
conjonctivalis Penel, 1905, see *loa*.
cystica Salisbury, 1868, see *Oxyuris* (*Oxyurias*) *vermicularis*.
diurna see *loa*.
dracunculus see *medinensis*.
hominis Diesing, 1851a (equals *lymphatica* renamed, type of *Hamularia*).
hominis bronchialis see *hominis*.
irritans Rivolta, 1884 (*Dermofilaria* Rivolta, 1884).
labiata Creplin, 1825a (? type of *Dicheilonema* 1861).
loa Cobbold, 1864 (*Loa* Stiles, 1905).
lymphatica Treutler, 1793 (*Hamularia* Treutler, 1793).
medinensis Linnæus, 1758a (*Dracunculus* 1759).
megalochila Diesing, 1851a (*Schizocheilonema* and *Tricheilonema* Diesing, 1861a).
muscæ Carter, 1861d (*Habronema* 1861).
mustelarum (pulmonalis) Rudolphi, 1819a (*Filaroides* Beneden, 1858a).
oculi Gervais & van Beneden, 1859b, see *loa*.
physalura Bremser, 1851 (? type of *Monopetalonema* 1861).
quadrilabiata Molin, 1861 (*Tetracheilonema* 1861).
rigida Siebold, 1836 (*Bradynema* zur Strassen, 1892).
subconjunctivalis Guyon, 1865a, see *loa*.

In connection with the genus *Filaria*, and to some extent in addition to the genera just mentioned, certain other groups come into consideration. Reference is made to the genera which Diesing, 1861a,[a] included in his family *Spiruridea*, namely, the following subfamilies:

1. *Acheilospiruridea*, with the genera *Spiroptera*, *Eucamptus*, *Proleptus*, *Histiocephalus*, *Dispharagus*, *Spiropterina;* and
2. *Cheilospiruridea*, with the genera *Spirura*, *Hystrichis*, *Echinocephalus*, *Cheilospirura*, and *Physocephalus*.

In reference to *Spiroptera*, it may be noticed that the following species have been made types of genera:

anthuris Rudolphi, 1819a (*Acuaria* Bremser, 1811; *Anthuris* Rudolphi, 1819; *Spiroptera* Rudolphi, 1819; *Dispharagus* Dujardin, 1845).
hamulosa Diesing, 1851a (*Cheilospirura* Diesing, 1861).

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[a] This paper was presented to the Academy on December 6, 1860, but does not appear to have been published until 1861. It is erroneously given as December 6, 1861, in Stiles & Hassall's Index Catalogue of Medical and Veterinary Zoology.

laticaudata Rudolphi, 1819a (? type of *Histiocephalus* Diesing, 1851).
scutata Mueller, 1869 (*Myzomimus* Stiles, 1892).
contorta Rudolphi, 1819a (*Spiroxys* Schneider, 1866).

Beside all the genera thus far mentioned, a zoological revision of the threadworms must also take into consideration certain other genera, such as *Physaloptera* (which some authors classify in the *Filariidæ*, others in the *Strongylidæ*, others as a distinct family), and several other genera, the systematic position of which is not definitely established. *Thelazia* Bosc, 1819, based upon *T. rhodesii* (compare *lacrymalis*) of cattle, must be considered in this connection.

Without attempting at present to revise the entire filaria group, which should probably be given superfamily rank, as *Filarioidea*, it is possible, in light of the type *Filaria* as now determined, to classify, to at least some extent, the threadworms reported for man. At least two subfamilies should be recognized for these worms, namely, *Dracunculiinæ* and *Filariinæ*.

Superfamily FILARIOIDEA new group.

Family FILARIIDÆ Braun, 1895.

1863: *Filaridea* Carus, 1863, 461.
1876: *Filariadæ* Leuckart, 1876a, 609–611.—Braun, 1883a, 160, 181.—Parona, 1887, 358.
1879: *Filaridæ* Cobbold, 1879b, 5.—Blanchard, 1895, 746.—Bos, 1894a, 218.—Braun, 1895b, 219.—Daniels, 1898e, 879–880.—Lepri, 1898a, 56.—Roger, 1901, 95.—Schneidemuehl, 1896, 306.—Stossich, 1898, 92.
1895: *Filariidæ* Braun, 1895b, 212–213.—Ransom, 1904, 20, 30, 31, 38, 40, 41.—Shipley, 1896, 147.
1899: *Filarides* Assenova, 1899, 104.

It is very difficult at present to write a satisfactory diagnosis of this family, but the following may be taken provisionally for this purpose:

Family diagnosis.—*Nematoda, Filarioidea:* Body filiform, rather long, in some cases about a meter in length. Head straight, often, if not always, with two lateromedian and four submedian papillæ; lateral lines more highly developed than median lines. Mouth terminal, variable, in some cases with two lips, occasionally with a more or less distinct buccal capsule; esophagus slender, elongate, may be divided into two portions, but has no posterior bulb; midgut present; rectum present; anus subterminal. All species parasitic. Development, at least in certain species, with change of host.

Male: With 1 to 2 unequal spicules; tail usually curved spirally, provided with papillæ, and in some cases with lateral alæ.

Female: Larger than male; vulva present or absent in gravid worms; when present, usually anterior; uterus double; usually ovoviviparous.

Type genus.—*Filaria* Mueller, 1787.

This family contains numerous species which have been placed in rather poorly defined genera.

There can be little doubt that the *Filariidæ* must be divided into several subfamilies. The typical subfamily will necessarily be *Filariinæ*, although the exact characters and extent of this subgroup can

scarcely be established at present. Whatever these characters may be, the genus *Dracunculus* is so distinct from the other forms that it may well be taken as representative of a special subfamily.

KEY TO TWO SUBFAMILIES OF FILARIIDÆ.

Vulva usually anterior, near mouth; spicules usually quite dissimilar. *Filariinæ* (p. 40)
Vulva absent in gravid stage, the female genital organs discharging through the mouth; male unknown .... *Dracunculiinæ* (p. 39)

Subfamily DRACUNCULIINÆ, new subfamily.

This subfamily is erected for the Guinea worm, *Dracunculus medinensis*, frequently called *Filaria medinensis*. The absence of a vulva in the adult stage is such a major character that this alone suffices to separate the worm from the true *Filaria*.

The generic and specific synonymy are as follows:

Genus DRACUNCULUS Kniphoff, 1759.

1689: *Dracunculus* Cunelius, 1689a, 395–428; Pre-Linnæan.
1712: *Dracunculus* Kæmpfer, 1712, 524–531; Pre-Linnæan.
1759: *Dracunculus* Kniphoff (1759), 12 (monotypical, *medinensis*) [not *Dracunculus* Wiegm., 1834, reptile; not *Dracunculus* fish, see Kroyer, 1838–40a, 422, syn. of *Callionymus lyra*].—Diesing, 1861a, 695–698 (includes *persarum* [=*medinensis*], *oculi*, *æthiopicus*).—Gallandat, 1773a, 103–116 (m. *medinensis*).
1773: *Vena* Gallandat, 1773a, 103–116 (m. *medinensis*).
1792: *Nervus* Laporte, 1792b, 531 (m. *medinensis*).
1896: *Dracuncuus* Moniez, 1896, 317, misprint.
1896: *Drakunkulus* Schneidemuehl, 1896, 306, for *Dracunculus*.
1905: *Draconculus* Penel, 1905, 67, misprint.

The type of this genus is the Guinea worm, also known as the Medina worm. Nearly all articles, both in medical and in zoological literature, which refer to *Dracunculus* deal with this parasite.

The Medina Worm—DRACUNCULUS MEDINENSIS (Linnæus, 1758) Gallandat, 1773.

1674: *Dracunculus veterum* Velsch (1674); Pre-Linnæan.
1674: *Vena medinensis* Velsch (1674); Pre-Linnæan.
1689: *Dracunculus* Cunelius, 1689a, 395–428, and of most authors; Pre-Linnæan.
1694: *Dracunculus persarum* Kæmpfer, 1694a; 1712, 524–535; Pre-Linnæan.
1740: *Vena medina* Grundler, 1740a, 329–330; Pre-Linnæan.
1758: *Gordius medinensis* Linnæus, 1758a, 647 (includes *Vena medinensis* and *Dracunculus persarum*); in *Homo;* India.
1760: *Dracunculus veterum* Pallas, 1760.
1773: *Vena medinensis* (Linnæus, 1758) Gallandat, 1773a, 103–116 [not of Larrey, 1812 (teste Blanchard, 1899e, 506)].
1773: *Dracunculus medinensis* (Linnæus, 1758) Gallandat, 1773a, 103–116.
1777: *Dracunculus græcorum* Gruner, 1777a, 257–264.
1781: *Dracunculus persarum* Fuchs, 1781a, 40 pp.
1790: *Filaria medinensis* (Linnæus, 1758) Gmelin, 1790a, 3039.
1795: *Furia medinensis* (Linnæus, 1758) Modeer, 1795, 143–167.

1819: *Filaria dracunculus* Bremser, 1819a, 194–221, pl. 4, fig. 1; *medinensis* renamed.
1838: *Filaria medeninsis* Alessandrini, 1838, 2; misprint.
1856: *Filaria æthiopica* Valenciennes, (1856), 259–261.
1861: *Dracunculus æthiopicus* (Valenciennes, 1856) Diesing 1861a, 698.
1863: *Dracunculus perlorum* Meissner, 1863, 51; misprint for *persarum.*
1893: *Filaria guinensis* Dunglison, 1893a, 440.
1896: *Dracuncuus medinensis* (Linnæus, 1758) Moniez, 1896, 317; misprint.
1896: *Filaria* (*Dracunculus*) *medinensis* (Linnæus, 1758) Shipley, 1896, 147, 157, 163.
1896: *Filaria æthiopika* Schneidemuehl, 1896, 306; for *æthiopica.*
1896: *Drakunkulus persarum* (Fuchs, 1781) Schneidemuehl, 1896, 306.
Vernacular names: Guinea worm, Medina worm, Beenwurm, Brackwasserwurm, Tankwurm, Nestlewurm (in part only), Filaria de Médine, Filaria de Medina, vers de Guinée, Dragonneau (in part; compare *Gordius*).

Subfamily FILARIINÆ, new subfamily.

The subfamily which contains *Filaria* must be named *Filariinæ.* Its full characters are not established at present, but one of its chief characters must be the presence of a vulva in the adult female.

Genus FILARIA Mueller, 1787.

The type of this genus must be carefully restudied before a satisfactory generic diagnosis (see p. 34) is written. For the present we may divide it into three subgenera, to contain the filariæ reported for man, but it is quite probable that these subgenera will later be given generic rank. *Thelazia* also comes into consideration as a possible subgenus of *Filaria.* For a list of the species of *Filaria* which have been taken as types of distinct genera see p. 37.

For the purposes of this paper the remaining species of "*Filaria*" reported for man will be arranged as follows:

A. Subgenus *Hamularia* Treutler, 1793.
B. Subgenus *Loa* Stiles, 1905.
C. Subgenus *Filaria* Mueller, 1787.
D. Subgenus uncertain.
  (a) Unstriated.
  (b) Striated.
  (c) Not stated.
  (d) Not satisfactorily established as occurring in man.
E. Collective group "*Microfilaria.*"
F. Species eliminated from subgenus *Filaria* and probably from genus *Filaria.*
G. Collective group *Agamofilaria.*
H. Genus *Filocapsularia.*
I. Species probably to be eliminated both from *Filaria* and *Filariidæ.*
J. Species definitely eliminated from genus *Filaria* and also from family *Filariidæ.*

A. Subgenus HAMULARIA Treutler, 1793.

1793: *Hamularia* Treutler, 1793, 10–13 (m. *lymphatica=equina*).
1800: *Tentacularia* Zeder, 1800a, 5; *Hamularia* renamed. [Not *Tentacularia* Bosc, 1797.]
1840: *Haularia* Lee, 1840a, 282; misprint.

Hamularia lymphatica has recently been identified with *Filaria equina*. The mouth, tail, and certain other characters of this worm differ so radically from *Filaria martis* that *equina* can scarcely be placed in the typical subgenus *Filaria*. It may at present be admitted to only subgeneric rank (for the sake of conservatism), but with the statement that it will probably soon be raised to generic rank. For this group the generic name *Hamularia* is at present available.

In this connection it should be stated that for years authors were not in accord as to the zoological position of *Hamularia*. Some authors have thought that the type *Hamularia lymphatica* is identical with *Strongylus longevaginatus* (= *Metastrongylus apri*). Leuckart first thought it was an *Ascaris mystax* (= *Toxocara*), but nearly all recent authors consider it a *Filaria*, while Linstow (1902, 222) and Braun (1903, 276) have accepted it as identical with *Filaria equina*. On authority of this latter interpretation, *Hamularia* may be considered as an available name for the subgenus in which *Filaria equina* is placed, unless it be shown that Linstow and Braun are in error in their conclusion. On their authority I accept their synonymy, and this acceptance makes it obligatory on me to use *Hamularia* in this place. The synonymy of the species in question is as follows:

FILARIA EQUINA (Abildgaard, 1789) Blanchard, 1849.

1781 or 1789: *Gordius equinus* Abildgaard (1781), v. 3, 49, pl. 109, fig. 12; (1789), 49; 1790, 28.
1790: *Filaria equi* Gmelin, 1790a, 3039.
1793: *Hamularia lymphatica* Treutler, 1793, 10–13, pl. 2, figs. 3–7; in *Homo*, Europe.
1802: *Filaria papillosa* Rudolphi, 1802a, 2–3.
1803: *Tentacularia subcompressa* Zeder, 1803a, 45; *Hamularia lymphatica*, 1793, renamed.
1809: *Hamularia subcompressa* (Zeder, 1803) Rudolphi, 1809a, 82–83.
1810: *Amularia linfatica* Brera, 1810a, 225–231; 1810b, pl. 4, figs. 1–3; for *Hamularia lymphatica* 1793.
1819: *Filaria bronchialis* Rudolphi, 1819a, 7 (syn. of *F. hominis bronchialis*) [not *F. bronchialis* (= *Metastrongylus*) of Veterinarian, 1857, of calves].
1819: *Filaria hominis bronchialis* Rudolphi, 1819a, 7, 215–216; *Hamularia lymphatica* 1793, renamed.
1823: ? *Ascaris pellucidus* Kennedy, 1823a, 107–111; in eye of horse; India.
1840: *Haularia subcompressa* (Zeder, 1803) Lee, 1840a, 282; misprint.
1840: *Filaire equi* (Gmelin, 1790) Lee, 1840a, 283; misprint.
1849: *Filaria equina* (Albildgaard, 1789) Blanchard, 1849a, 154–155, pl. 6, fig. 3.
1851: *Filaria hominis* Diesing, 1851a, 279, 535, 567; *Hamularia lymphatica* 1793, renamed [not *F. hominis* for *F. sanguinis hominis*].

1859: *Filaria bronchialis hominis* Gervais & van Beneden, 1859b, 145; *Hamularia lymphatica* 1793, renamed.
1860: *Filaria lymphatica* (Treutler, 1793) Moquin-Tandon, 1860a, 337.
1860: *Trichosoma subcompressa* (Zeder, 1803) Moquin-Tandon, 1860a, 337, apparently lapsus.
1876: *?Filaria sanguinis equi* Sonsino, (1876).
1876: *Filaria bronquialis hominis* de Bonis, 1876a, 130, pl. 2, fig. 2.
1879: *Strongylus (Filaria) bronchialis* (Rudolphi, 1819) Cobbold, 1879b, 207–208.
1894: *Filaria equie* Francis, 1894a, 451; misprint for *equina*.
1894: *?Filaria pellucida* (Kennedy, 1823) Dolley, 1894a, 994 (as young of *F. equina.*)
1896: *Filaria hamulosa* Schneidemuehl, 1896, 308.

B. Subgenus LOA Stiles, 1905.

1905: *Loa* Stiles in Stiles & Hassall, 1905, Dec., 150 (m. *loa;* in man, Africa).

The species *Filaria loa* differs so from the other filariæ of man, in the presence of bosses on the skin and in the form of the caudal papillæ that it may well be taken as the type of a special subgenus. This group also will probably eventually prove to be of generic value, as Cobbold has already suggested.

The loa—FILARIA LOA (Cobbold, 1864).

1812: *Vena medinensis* of Larrey, 1812 (teste Blanchard, 1899e, 506) [not of Gallandat, 1773a].
1845: *Filaria lacrymalis* Dujardin, 1845a, 46 [not Gurlt, 1831a]; Dubini, 1850b, Mar. 4, 576; 1850b, Apr. 20, 21–22; in *Homo;* not *F. lacrymalis* Gurlt, 1831, in horse.
1850: *Filaria lacrimalis* Dubini, 1850b, Mar. 4, 577; for *lacrymalis*.
1859: *Filaria oculi* Gervais & Beneden, 1859b, 142–144; [not *F. oculi* Siebold, 1839, 158, based on Ammon, 1838, figs. 22, 23; not *F. oculi* Clarkson, 1845a, of horses; not *F. oculi* of parrots].
1860: *Dracunculus oculi* (Gervais & Beneden, 1859) Diesing, 1861a, 697. [Possibly this combination was used by Cobbold at an earlier date.]
1864: *Dracunculus loa* Cobbold, 1864b, 147, 388–389 [the name was probably used by Cobbold in some earlier publication].
1865: *Filaria subconjunctivalis* Guyon, 1865a, 58–59.
1866: *Filaria loa* (Cobbold, 1864) Aitken, 1866, 881.
1878: *Filaria lou* Zool. Rec., v. 13 (1876) 1878, Verm., 17; misprint.
1891: *Filaria sanguinis hominis major* Manson, 1891, Jan. 3, 4; sheathed diurnal larva in blood.
1891: *Filaria diurna* Manson, 1891, Aug. 26, 203 (larval form in blood of *Homo* in Africa).
1891: *Filaria sanguinis hominis diurna* Manson, 1891, Aug. 26, 202.
1900: *Filaria sanguinis diurna* Linstow, 1900, 76.
1901: *Filaria lao* Vaullegeard, 1901, 128; misprint for *loa*.
1904: *Filaria bourgii* Brumpt, 1904, — (larval form in blood).
1905: *Draconculus oculi* (Gervais & Beneden, 1859) Penel, 1905, 67; misprint.
1905: *Draconculus loa* (Cobbold, 1864) Penel, 1905, 67; misprint.
1905: *Filaria conjonctivalis* Penel, 1905, 67; misprint.
1905: *Filaria bourgi* Penel, 1905, 75, 82; for *bourgii*.
1906: *Microfilaria diurna* (Manson, 1891) Shipley & Fearnsides, 1906, 18.

C. Subgenus FILARIA Mueller, 1787.

For synonymy see p. 36.

Some species of *Filaria* are described as possessing a transverse striation, others as without such striation. A difference of this kind, if constant in the species in question, would probably represent at least a subgeneric, possibly a generic character—that is, assuming the striation to be distinct, as we find it in certain other groups of *Nematoda*. The exact nature of the striation reported for some of the *Filariidæ* may well be restudied, however, for it does not seem to be excluded that at least in some cases a pseudostriation may perhaps have been erroneously interpreted as a true striation. According to Alessandrini, *Filaria martis* (the generic type) is not transversely striated. Until this species is restudied it can not be positively stated which other species of *Filaria* should be placed in the typical subgenus, and while it is possible that some of the forms which are found in man may belong here, this point may well be left open until the generic type is better understood.

D. Subgenus uncertain.

Until *Filaria martis* is restudied, in order to determine the characters of the typical subgenus, the exact systematic subgeneric position of the following parasites of man (and also of nearly all the other species of *Filaria* reported for different animals) remains *sub judice*.

(a) Species reported as not possessing a transverse striation on the cuticle:

Bancroft's Filaria—FILARIA BANCROFTI Cobbold, 1877.

1872: *Filaria sanguinis hominis* Lancet, London, 1872, Aug. 31, 310; based on Lewis's work; Busk responsible for generic determination; larval form, in blood of *Homo;* Calcutta.—Manson, 1891, Jan. 3, 4, restricted to nocturnal sheathed larva in blood.

1874: *Filaria sanguinis hominis ægyptiaca* Sonsino, (1874).

1875: *Filariose dermathemica* Silva Araujo, 1875; da Silva Lima, 1877, Sept., 389; apparently as name of disease; for craw-craw in Bahia—Cobbold, 1878b, 362,365, apparently as name of parasite, in synonymy of *F. bancrofti*.

1875: *Filaria dermathemica* Silva Araujo, 1875, 39–86; in *Homo*, Brazil.

1877: *Filaria bancrofti* Cobbold, 1877g, July 14, 70–71; adult, in *Homo*, Queensland, Australia.

1877: *Filaria wuchereri* Silva Lima, 1877, Sept., 395.

1877: *Wuchereria filaria* Silva Araujo, 1877, Nov., 492–504; possibly lapsus for *Filaria wuchereria*, or possibly as new name.

1877: *Filaria wuchereria* Felicio dos Santos, 1877, Mar., 137; 1877, Dec., 539; same as *F. wuchereri;* in elephantiasis of scrotum; Rio de Janeiro.

1877: *Filaria vuchereira* Magalhães in Silva Lima, 1877, Dec., 544.

1877: *Filariu sanguinis hominis* Magalhães, in Silva Lima, 1877, Dec., 544; misprint.

1878: *Filaria sanguinis* Beneden, 1878a, 276; of man; not *F. sanguinis* of dogs, of frogs, and of other animals.

1878: *Filaria sanguinolenta* Brit. M. J., teste Cobbold, 1878c, 366; of man, not of dogs.
1878: *Filaria sanguinis hominis egyptiaca* Bourel-Roncière, 1878a, 122; for *F. s. h. ægyptiaca*.
1879: *Filaria wucherii* Fayrer, 1879b, 189; for *wuchereri*.
1879: *Filaria dermithemica* Fayrer, 1879b, 189; misprint.
1879: *Filaria bancroftii* Fayrer, 1879b, 189; for *bancrofti*.
1883: *Filaria bankrofti* Braun, 1883a, 183; for *bancrofti*.
1883: *Filaria ægyptiaca* (Sonsino, 1874) Braun, 1883a, 183.
1883: *Filaria sanguinis humani* La Clinica de Malaga, 1883, 309.
1884: *Filoria sanguinis hominis* (Lancet, 1877) Calmette, 1884a, 456: misprint.
1885: *Filaria sanguinis hominum* Hall, 1885a, 40, for *F. s. hominis*.
1889: *Filaria hominis*—Author?—, 1889, for *F. sanguinis hominis*.
1889: *Filaria sanguis hominis* Gwynn, 1889a, 43–47; for *F. sanguinis hominis*.
1891: *Filaria nocturna* Manson, 1891, Aug. 26, 204; larva in blood.
1891: *Filaria sanguinis hominis nocturna* Manson, 1891, Aug. 26, 204.
1892: *Filaria sanguinis* Manson, 1892, 79; for *F. sanguinis hominis*.
1893: *Filaria cystica* (Salisbury, 1868) Railliet, 1893a, 515, in part only; not *F. cystica* Rudolphi, 1819a.
1896: *Trichina sanguinis hominis nocturna* (Manson, 1891) Huber, 1896a, 604; lapsus for *Filaria s. h. n.*
1896: *Filaria mansoni* Huber, 1896a, 604; not *F. mansoni* Cobbold, 1879b, of chickens.
1896: *Filaria sanguinis hominis nocturnæ* Henry, 1896g, 669, for *F. s. h. nocturna*.
1901: *Filaria sanguinis nocturna* Vickery, 1901, June 15, 206, for *F. s. h. nocturna*.
1903: *Filaria sanguinis hominis nocturnis* Johnstone, 1903a, 34–42, for *F. s. h. nocturna*.
1905: *Filaria dermatemica* Penel, 1905, 11, 13; for *dermathemica*.
1906: *Microfilaria nocturna* (Manson, 1891) Shipley & Fearnsides, 1906, 17.
?——: *Filaria sanguinis hominis bancrofti*.
Vernacular names: Vers de la Guadeloupe, Vers de Bresil, the hæmatozoon, Lewis's filaria, Chinese filaria, Wucherer's filaria.

In the foregoing synonymy I have included the names which are usually supposed to apply to the species in question. It may be pointed out, however, that the possibility is not entirely excluded that some of the names really apply to distinct subspecies, or possibly to distinct species. Is, for instance, the true *F. bancrofti* (type locality Australia) really identical with the Egyptian and the Brazilian worms which are usually classified in this species? This point needs further study.

In connection with the forms in question the names *Filariose*, *Wuchereria*, and *Microfilaria* (see p. 46) come up for consideration in case *F. bancrofti* eventually proves to be generically or subgenerically distinct from *F. martis*. As I interpret these names, *Filariose* was originally used as technical term for the disease, and it was later misquoted as a generic name. I rather doubt whether this would be available as generic name from the date of its misquotation. *Wuchereria* might be interpreted as a true generic name, although the possibility is not excluded that it was only used accidentally as such. *Microfilaria* seems to have been proposed distinctly as a collective name for the embryonic or larval stage and does not, I believe, have any right to priority as a true generic name. There is, however, some legitimate room for a difference of opinion on these points.

FILARIA PERSTANS Manson, 1891.

1891: *Filaria sanguinis hominis minor* Manson, 1891, Jan. 3, 4; larva in blood of *Homo;* no sheath, no periodicity. Quadrinominal used for a "distinct species," hence it has no nomenclatural status and does not therefore take precedence over *Filaria perstans.*
1891: *Filaria perstans* Manson, 1891, Aug. 26, 203; larva in blood of *Homo* from Africa.
1891: *Filaria sanguinis hominis perstans* Manson, 1891, Aug. 26, 202; 1892, 79.
1892: *Filaria perstams* Manson, 1892, 85; misprint.
1902: *Filaria sanguinis perstans* Fagge & Pye Smith, 1902, 474.

(b) Species which are reported as possessing transverse striations on the cuticle:

? FILARIA BANCROFTI.

See p. 43. Some authors report transverse striations for this species.

FILARIA CONJUNCTIVÆ Addario, 1885.

1823: *? Ascaris pellucidus.* See also p. 41.
1867: *? Filaria palpebralis* Pace (1867). in *Homo;* not Wilson, 1844, of horses.
1879: *Filaria peritonei hominis* Babès, 1879a, 554; in *Homo;* Budapest.
1880: *Filaria peritonæi hominis* Babès, 1880a, 158–165, for *F. peritonei hominis.*
1885: *Filaria conjunctivæ* Addario, 1885, 135–148, figs. 1–8; in *Homo;* Catania, Italy.
1887: *Filaria inermis* Grassi, 1887g, 617–623, figs. 1–3; *F. conjunctivæ* 1883, renamed.
1892: *Filaria apapillocephala* Condorelli-Francaviglia, 1892e, 168–179.
1894: *? Filaria pellucida.* See also p. 42.
1899: *Filaria conjunctivæ* Assenova, 1899, 50, 110, 103; misprint.
1905: *Filaria conjonctivæ* Penel, 1905, 8; misprint.

Magalhães's Filaria—FILARIA MAGALHÃESI Blanchard, 1895.

1887: "*Filaria bancrofti*" of Magalhães, 1887, 126–219, misdetermined; heart of *Homo;* Rio de Janeiro, Brazil.
1892: *Filaria sanguinis hominis* of Magalhães, 1892, 7. Oct., 513, fig. 2, not *F. s. h.* of *F. bancrofti.*
1895: *Filaria magalhãesi* Blanchard, 1895, 771, 782–783, based on Magalhães, 1887, 126–219.
1897: *Filaria megalhaesi* Manson, 1897, Dec. 25, 1837; misprint.
1898: *Filaria magalhaes* Daniels, 1898a, 1012; misprint.
1901: *Filaria magalhãesi* Annett, Dutton & Elliott, 1901, Sept., pt. 2, 43, 47, 49.
1901: *Filaria megalhäsi* Manson, 1901, 562; misprint.
1903: *Filaria magalhaësi* Manson, 1903, 3 ed., 546, 604.
1903: *Filaria megalhaes* Daniels, 1903, 121; misprint.
1905: *Filaria magalhesi* Penel, 1905, 113; misprint.

FILARIA VOLVULUS Leuckart, 1892.

1892: *Filaria volvulas* Leuckart, in Manson, 1892, 88; evidently misprint for *volvulus.*
1893: *Filaria volvulxus* Leuckart, in Manson, 1893, 963; evidently a typographical error for *F. volvulus.*
1893: *Filaria volvulus* Leuckart, in Manson, 1893, 963, corrected form of *F. volvulxus;* in *Homo;* Gold Coast, Africa.

(c) Transverse striation neither affirmed or denied:

Demarquay's Filaria—FILARIA DEMARQUAYI Manson, 1897.

1897: *Filaria demarquayi* Manson, 1897, Dec. 25, 1837–1838; in *Homo;* St. Vincent.
1897: *Filaria ozzardi* Manson, 1897, Dec. 25, 1838 (in part, namely, sharp tailed form).—Blanchard, 1905a, 537.
1899: *Filaria demarquaii* Galgey, 1899a, 145–146; for *demarquayi.*
1905: *Filaria demarquagi* Penel, 1905, 92; misprint.
1905: *Filaria demarquii* Linstow in Low, 1905d, 39.

Ozzard's Filaria—FILARIA OZZARDI Manson, 1897.

1897: *Filaria ozzardi* Manson, 1897, Dec. 25, 1838, figs. 5–6; in *Homo;* British Guiana.
1902: *Filaria ozzardii* Daniels, 1902, Dec. 1, 358; for *ozzardi.*

(d) Not satisfactorily established as occurring in man:

The cruel filaria—FILARIA IMMITIS Leidy, 1856.

1850: *Filaria canis cordis* Leidy, 1850f, 118 (in heart of *Canis familiaris;* U. S. A.); 1856a, 2; 1856b, 55; 1880b; 1904a, 40, 101, 157.
1852: *Filaria papillosa hæmatica canis domestici* Gruby & Delafond (1852).
1856: *Filaria immitis* Leidy, 1856b, 55; 1880b; 1904a, 101, 157; *F. canis cordis* named binominally.
1866: *Filaria papillosa hæmatica* Schneider, 1866a, 87.
1875: *Filaria hæmatica* Ercolani, 1875e, 38.—Galeb & Pourquier, 1877a, 271–273 (congenital case in dog); 1877b, 95; 1877c, 127–129; 1877f, 352.
1875: *Spiroptera immitis* (Leidy, 1856) Ercolani, 1875e, 38.
1877: *Filaria ematica* Galeb & Pourquier, 1877d, 140–141 (for *F. hæmatica*).
1879: *Filaria iminitis* Fayrer, 1879b, 222; misprint.
1886: *Filaria sanguinis immitis* Vet. J., 1886, 230.
1896: *Filaria papillosa hæmatika* Schneidemuehl, 1896, 307.
1897: *Filaria papillosa ematica* Giuseppi, 1897a, 185.
1902: *Filaria inmitis* Daniels, 1902, 47; misprint.
1904: *Filaria immilis* Leidy, 1904a, 157; misprint.
——: *Filaria canina.*

E. Collective group "MICROFILARIA"—Larval filaria in the blood.

The following species of "*Filaria*" have been based upon larval forms found in the blood of man. It is impossible to place them subgenerically until the adult stage is studied. The name *Microfilaria* appears to me to have the status of a collective group rather than a generic status. It refers to microscopic larval or embryonic filariæ found in the blood.

FILARIA PHILIPPINENSIS Ashburn & Craig, 1906.

1906: *Filaria philippinensis* Ashburn & Craig, 1906, Sept., 435–443, figs. 1–5, in blood of *Homo*, at Manila, P. I., day and night, sheath present; 1906, Sept. 8, 514.

FILARIA POWELLI Penel, 1905, species dubia.

1905: *Filaria powelli* Penel, 1905, 126, based on Powell, 1903, May 16, 1145 (*Homo;* Bombay, India).—Blanchard, 1905a, 538.
1905: *Filaria povelli* Penel, 1905, 10, for *F. powelli.*

FILARIA sp. Cholodkowsky, 1896.

1896: *Filaria* sp. Cholodkowsky, 1906, 59; 1907, 185.—Braun, 1903, 3 ed., 278; in *Homo*; Tver.

FILARIA sp. O'Neill, 1875.

1875: *Filaria* sp. O'Neill, 1875, Feb. 20, 265–266, fig. 1 (in *Homo*, cases of craw-craw; West Coast of Africa); 1875, 229; 1898, 204.—Braun, 1883a, 182.—Cobbold, 1878h, 370.

FILARIA sp. Prout, 1902.

1902: *Filaria* sp. Prout, 1902, Sept. 20, 880; in blood of *Homo*, in Freetown, Sierra Leone, West Africa; 1902, Oct. 15, 318.

F. Species to be eliminated from FILARIA (FILARIA).

The following species should doubtless be eliminated from *Filaria* (*Filaria*), but their exact generic and subfamily position is *sub judice*:

(FILARIA?) LABIALIS Pane, 1864.

1864: *Filaria labialis*, Pane, (1864), 32–34 (in *Homo;* Naples, Italy).—Addario, 1885, 143.—Anders, 1903, 1258.—Annett, Dutton & Elliott, 1901, 1, 4.—Assenova, 1899, 50, 52–53, 102, 120.—Beneden, 1878a, 278.—Blanchard, 1890a, 14–15, fig. 391; 1895, 785.—de Bonis, 1882, 123.—Braun, 1883a, 182; 1895, 227; 1903, 3ed., 275–276.—Cobbold, 1879b, 207.—Davaine, 1877a, cvii.—Dunglison, 1893a, 440.—Huber, 1896, 501.—Ijima, 1889b, 345.—Leuckart, 1876, 616–618, fig. 307.—Moniez, 1896, 359–360.—Mosler & Peiper, 1894, 218–219.—Packard, 518.—Penel, 1905, 8.—Stoss., 1897, 31.—Tyson, 1903, 1197.—Vaullegeard, 1901, 124.—Vogt, 1878, 11, 13.—Ward, 1895, 331; 1903, 212; 1903, 704.—Wood & Fitz, 1897, 342.

The position of the vulva, if correctly interpreted, excludes this worm from the genus *Filaria*.

(FILARIA?) KILIMARÆ Kolb, 1898.

1898: *Filaria kilimaræ* Kolb, 1898a, Feb., 28–33 (in *Homo*, etc.; Kilimara, British East Africa); 1898b, 633–634; 1898c, 300.—Braun, 1903, 3. ed., 277–278.—Looss, 1905, 180.—Penel, 1905, 8.—Ward, 1903, 704.

(FILARIA?) ROMANORUM ORIENTALIS Sarcini, 1888.

1888: *Filaria romanorum orientalis* Sarcini, 1888, Feb. 12, 222 (in blood of *Homo sapiens;* Roumania).—Blanchard, 1895b, 168–169 (nature very problematic); 1895, 786.—Braun, 1903, 3. ed., 277.—Ward, 1903, 215; 1903, 704.

G. Collective group AGAMOFILARIA Stiles, 1907.

As stated on p. 10 I propose to use the term *Agamofilaria* as name of a collective group, in which may be placed the agamic or immature filarial worms which can not at present be more definitely classified. The following forms come into consideration in connection with the parasites of man.

AGAMOFILARIA GEORGIANA Stiles, 1907.

See p. 11 of this bulletin.

(AGAMOFILARIA?) OCULI (Siebold, 1839) Stiles, 1907, species dubia.

1832: *Filaria oculi humani* Nordmann, 1832, 7–8; in *Homo;* Berlin, Germany; 1843, 67.
1839: *Filaria oculi* Siebold, 1839, 158, based on Ammon, 1838, figs. 22, 23, in *Homo;* not *F. oculi* Clarkson, 1845a, of horses; not *F. oculi* of parrots; not *F. oculi* Gervais & Beneden, 1859, see *F. loa.*
1851: *Filaria lentis* Diesing, 1851a, 265; binominal for *F. oculi humani.*
1880: *Filaria oculis* Chiralt, 1880a, 2–9, 1 fig.; 1882a, 473–480.
1896: *Filaria okuli humani* Schneidemuehl, 1896, 304.
1901: *Filaria oculi hominis* Vaullegeard, 1901, 129.

Diesing's (1851) specific name *lentis* is usually adopted for this species, but so far as I can find, *oculi*, 1839, is the first available name.

H. Genus FILOCAPSULARIA Deslongchamps, 1824.

1824: *Filocapsularia* Deslongchamps, 1824q, 398–400 (m. *communis* Deslongchamps, 1824q, 399–400, a species which includes a number of previously named species).

One alleged parasite of man (namely, *Spiroptera hominis*=*Filaria piscium*) should apparently be classified in this genus. The exact position of the genus is uncertain.

"SPIROPTERA HOMINIS" Rudolphi, 1819.

1809: *Filaria piscium* Rudolphi, 1809a, 74–75.—Meissner, 1863, 55.
1819: *Spiroptera hominis* Rudolphi, 1819a, 27, 250–253 (in *Homo*, female: London).—Beneden, 1878a, 279 (sym. of *Filaria piscium*).—Gervais & van Beneden, 1859a, 146–147.—Guès, 1879a, 181.—Meissner, 1863, 55 (syn. of *Filaria piscium*).
1824: *Filocapsularia communis* Deslongchamps, 1824q, 399–400; in fish.
1825: *Spiroptera rudolphi* delle Chiaje, 1825, 7–8, pl. 1, fig. 3; *S. hominis* renamed.
1825: *Spiroptera rudolphiana* delle Chiaje, 1825a 7, apparently intended as Italian for *S. rudolphi*, but accepted by some later authors (as Blanchard, 1889d, 706) as a Latin name.
1851: *Agamonema commune* (Deslongchamps, 1824) Diesing, 1851a, 120–121; in fish.
1851: *Strongylus gigas pullus* Diesing, 1851a, 223 (refers to Bremser, 1819a, 226, pl. 4, figs. 6–10), as syn. of *Spiroptera hominis.*
1851: *Spiroptera rudolphii* Diesing, 1851a, 223 (for *S. rudolphi*) as syn. of *Sp. hominis.*

This was a spurious parasite. It was afterwards shown to be *Filaria piscium*, a species which is classified as *Filocapsularia communis* or *Agamonema piscium.*

I. Species probably eliminated from FILARIA and FILARIIDÆ.

The following species can be probably eliminated, not only from the genus *Filaria*, but also from the family *Filariidæ.*

(FILARIA?) HOMINIS ORIS[a] Leidy, 1850? = MERMITHIDÆ

1850: *Filaria hominis oris* Leidy, 1850f, 117; (in mouth of a child; U. S. A.); 1856b; 1904a, 40, 101 (as possible syn. of *F. medinensis*).—Anders, 1903, 6 ed., 1258.—Anderson, 1903, 1258.—Annett, Dutton, Elliott, 1901, 14.—Beneden, 1878a, 278.—Blanchard, 1890a, 13–14; 1895, 785.—Braun, 1883a, 182; 1895b, 227; 1903, 3 ed., 275.—Cobbold, 1879b, 207.—Dunglison, 1893a, 440.—Leuckart, 1876, 617.—Lewis, 1879, 257.—Moniez, 1896, 359.—Packard, ——, 518.—Penel, 1895, 8.—Tyson, 1903, 3 ed., 1198.—Ward, 1895, 330; 1903, 704; 1903, 212.

Specific Diagnosis.—*Filaria*?: "Body, white, opaque, linear, thread-like; mouth round, simple; posterior extremity obtuse, furnished with a short, curved, epidermal hooklet 1-500th in. in length by 1-2000th in. in diameter at base. Length, 5 inches 7 lines; greatest breadth, 1-66th in.; breadth at mouth, 1-250th in.; at posterior extremity 1-80th in."—Leidy, 1850f, p. 117.

Habitat.—Obtained from mouth of a child.

Medical Significance.—At the present time this species is without any medical significance, and from the original description of the worm it is impossible to pass any positive judgment upon it from a zoological point of view. The question naturally arises, however, whether this worm was not in reality a hair worm (possibly *Mermis*), which accidentally gained access to the mouth, possibly through eating an apple. On several occasions worms which were found in apples have been sent to me; they were probably parasitic in some insect, which in turn was parasitic in an apple; they agree fairly well with Leidy's original short description of *Filaria hominis oris*, and possess the "epidermal hooklet" on the end of the tail. Such worms could easily gain access to the mouth through eating apples.

Leidy's description does not apply very well to the genus *Filaria;* furthermore, it would be rather strange to find a true *Filaria*, 5 inches long, in the mouth. While no positive opinion can be expressed unless Leidy's original specimen[b] can be found, I incline to the view that *Filaria hominis oris* was probably a *Mermis*. Such a worm would probably be of very slight, if of any, medical importance.

(FILARIA?) GIGAS Prout, 1902, species dubia = ?Insect hairs.

1902: *Filaria gigas* Prout, 1902, Sept. 20, 880 (in *Homo*; Moyamba, Sierra Leone, West Africa); 1902, Oct. 15, 318–319; 1905, Sept. 16, 683.—Blanchard, 1905a, 538.—Looss, 1905c, 170 (possibly only a sheath).—Low, 1905b, 1329–1330 (probably insect hairs).—Manson, 1903, 546, 604.—Penel, 1905, 5, 10, 81, 125, 141, 147.

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[a] This name is here retained although, being a specific trinominal, it has no status in nomenclature as a specific name. Since however the species is so doubtful, there is no object in giving to it another name. As here used, *Filaria hominis oris* simply represents the Latin for "a filaria in the mouth of man."

[b] Edw. J. Nolan, secretary of the Academy of Sciences, Philadelphia, informs me that the original specimen can not be found in Philadelphia, and that it has probably been destroyed.

NEMATOIDEUM TRACHEALE Cobbold, 1864.

1855: *Entozoon found in the larynx* Rainey, 1855, 370–372, pl. 17, fig. 1.
1864: *Filaria trachealis* Cobbold, 1864b, 333 (based on Rainey, 1855, 370; syn. *Nematoideum tracheale*, as possibly referable to *Ascaris megalocephala* or *A. suilla*); 1866a, 7; 1867a, 6; 1883w, 513.—Anders, 1903, 6 ed., 1258.—Blanchard, 1888a, 740, 741, fig. 364; 1888r, 39 ("perhaps *Strongylus longevaginatus*"); 1895, 755 (syn. of *Strongylus apri.*)—Dunglison, 1893a, 821; 1900a, 821 (or *bronchialis*).—Looss, 1905c, 154 (as possibly identical with *Strongylus paradoxus*).—Moniez, 1896, 389 (as possibly identical with *Strongylus paradoxus*).—Packard, ——, 518.—Verrill, 1870, 171.—Ward, 1903, 219 (as possibly identical with *Strongylus apri*).
1864: *Nematoideum tracheale* Rainey & Bristowe, teste Cobbold, 1864b, 333 (as syn. of "? *Filaria trachealis*"); 1866a, 6; 1867a, 6. [I can not find where Rainey & Bristowe used this name.]
1879: *Filaria* (*Nematoideum*) *trachealis* of Cobbold, 1879b, 207.

J. Species to be eliminated from FILARIIDÆ.

The following species can be definitely eliminated from the family *Filariidæ:*

AGAMOMERMIS RESTIFORMIS (Leidy, 1880) Stiles, 1907.

1880: *Filaria restiformis*, Leidy, 1880c, June 1, 130–132, figs. 1–2 (in *Homo;* West Virginia); 1904a, 157–159, 278.—Blanchard, 1890a, 13, fig. 390a–b; 1895, 785.—Braun, 1883a, 184; 1895b, 227; 1903, 3. ed., 275.—Ijima, 1889b, 367.—Moniez, 1896, 359.—Penel, 1905, 8.—Stossich, 1897, 78.—Vaullegeard, 1901, 128.—Ward, 1895, 331; 1903, 704; 1903, 212.

In a later paper I will show that this species, of which I have found the type specimen, belongs to the *Mermithidæ*.

"FILARIA CYSTICA" (Salisbury, 1868) = OXYURIS VERMICULARIS.

1868: *Trichina cystica* Salisbury, 1868, April, 376–377, figs. 29–31; in bladder of *Homo* (female); Cleveland, Ohio, U. S. A.—Blanchard, 1897e, 167 (syn. of *Filaria sanguinis hominis*).—Bourel-Roncière, 1878a, 116; 1888a, 131.—Cobbold, 1880e, 58.—Cunningham, 1873a, 835–836, fig. 2 (there is reason to suspect that this is *Oxyuris vermicularis*).—Fayrer, 1879b, 189.—Huber, 1896a, 604 (syn. of *Filaria sanguinis hominis*).—Leuckart, 1876a, 637.—Lewis, 1879c, 247–249, fig. 1 (does not believe it is *F. s. hominis*).—Penel, 1905, 2 ed., 11, 12.—Railliet, 1893a, 515 (syn. of *Filaria bancrofti*).—Ransom, 1904, 25.— da Silva Lima, 1877, Nov., 489.—Stiles, 1905, IV. 29, 682 (syn. of *Oxyuris vermicularis*).—Ward, 1895, 320, 321 (syn. of *Filaria bancrofti*); 1903, 213.
1868: *Filaria cystica* (Salisbury, 1868) Cobbold, 1879b, 202.—Dolley, 1894a, 993 (syn. of *Filaria sanguinis hominis*); 1901, 993.—Linstow, 1900c, 76.—Moniez, 1896, 338.—Railliet, 1893a, 515.—Shipley, 1896, 142.—Stiles, 1905, IV. 29, 682.
1879: *Filaria salisburyii* Cobbold, 1879b, 188; *Trichina cystica* 1868, renamed.
1894: *Filaria salisburyi* Dolley, 1894a, 1901a, 994; for *salisburyii*.
1896: *Trichina cystika* Schneidemuehl, 1896, 306; for *cystica;* as syn. of *Filaria sanguinis hominis*.

There can be scarcely any reasonable doubt regarding the identity of this form with the common pinworm, *Oxyuris* (*Oxyurias*) *vermicularis*, of man.

FILARIA NIELLYI (Blanchard, 1885) Moniez, 1889=RHABDITIS NIELLYI.

1882: "*Anguillula leptodera*?" Nielly, 1882, 16 April, 395–405; in *Homo*, near Brest; 1882, Mai, 337–345, figs. 1–3.
1885: *Leptodera niellyi* Blanchard (1885), —— based on Nielly, 1882, 337–345, figs. 1–3. [Original publication not found.]
1888: *Rhabditis niellyi* (Blanchard 1885) Blanchard (1888). [Original publication not found.]
1889: *Filaria niellyi* (Blanchard 1885) Moniez, 1889, 192.

FILARIA ZEBRA Mongrand, 1852, species fictitia.

1852: *Filaria zebra* Mongrand 1852, Feb. 1, 63–64 (in vena saphena interna of a convict, *Homo*, at Brest).—Blanchard, 1889d, 706.—Moquin-Tandon, 1860, 388.

This spurious parasite, described by Mongrand, has been recognized by Davaine & Robin as a fibrinous clot.

THREE NEW AMERICAN CASES OF INFECTION OF MAN WITH HORSE-HAIR WORMS (SPECIES PARAGORDIUS VARIUS), WITH SUMMARY OF ALL CASES REPORTED TO DATE.

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(Figs. 35–55.)

There is a popular belief, extending back for centuries, that horse-hair worms (*Gordiidæ*), if swallowed by man or animals, will cause very serious, even fatal, disease; but the actual cases of such infections thus far definitely recorded in medical and zoological literature are but few in number; and medical men who have reported cases do not share the belief of the laity relative to the supposed dangerous character of these worms.

In recent years I have had specimens from two such cases referred to me for identification, and have seen another specimen from an unpublished case, and this has led me to consult the original references of all reported cases, so far as the literature is accessible to me.

The worms in question belong to the *Gordiacea*, a group of worms classified by some authors as a family of nematodes, by others as a distinct order of the *Nemathelminthes*. Their general relations to the other round worms may be seen from the following key:

KEY TO THE ORDERS OF NEMATHELMINTHES.

[For forms known to occur in man in the United States, follow roman type.]

1. *Anterior end provided with a proboscis, armed with several rows of thorns or hooks; intestine absent; adults parasitic in intestine; very rare in man; thorn-headed worms* .... *Acanthocephala*

   Anterior end not provided with a thorny proboscis; intestine present, complete or in part rudimentary 2
2. Intestinal canal of adult usually complete, but in some cases (*Mermithidæ*) represented by esophagus and rudimentary intestine; papillæ on head; spicules usually present in male; one testicle present in male; vulva always independent of anus except in *Cloacina;* most round worm parasites of man belong here .... *Nematoda*

   Intestinal canal always atrophied anteriorly in adult; head without papillæ; spicules never present in male; two testicles present in male; vulva always united with posterior portion of intestine to form a cloaca; rare in man and then only as accidental parasites; horse-hair worms .... *Gordiacea*

The technical name *Gordiacea* is based upon the name of the type genus *Gordius*, and this in turn is taken from the fact that the worms have a habit, when in water, of entangling themselves, several together, into an inextricable mass, thus recalling the "Gordian knot."

The popular name "horse-hair worm" is taken from the popular, though of course erroneous, idea that these worms develop from horse hairs. In reality, the larval stages are parasitic, chiefly in insects, while normally the adults are free living.

It occasionally occurs that these worms are vomited by man or that they are passed in the stools. Authors are not agreed as to the method of infection. Some writers are of the opinion that the larval worm is swallowed and then develops further in man, while other writers hold that the adults are accidentally swallowed while a person is drinking at a fountain or brook.

The following is a tabular statement of 15 cases which I have been able to find recorded, together with three new cases:

Date.	Species of parasite.	Passed per—	Patient. Sex.	Patient. Age (years).	Locality.	Collector.	Authority.[a]
ante 1638	*Vitulus aquaticus = Gordius aquaticus*	Mouth	Male	Adult.	Italy	? Helvetius	Aldrovandus, 1638a.
ca. 1821	"*Gordius aquaticus*" = *Parachordodes tolosanus.*	do	do	8	France		Degland, 1821a, 1823a.
ca. 1822	*Ophiostoma ponterii = Parachordodes tolosanus.*	do	do	Adult?	Uzerches, France	Raymond Pontier	Cloquet, 1822a-b.
1853	*Gordius aquaticus*	do	Female	22	Bavaria	Dr. Hessling	Siebold, 1854.
ante 1861	*Paragordius varius*	Anus	do	Young.	Ohio, U. S. A	Kirtland	Diesing, 1861a.
ca. 1875	*Gordius aquaticus*	do	Male	8	Dalmatia, Austria		Patruban, 1875.
ante 1881	*Parachordodes tolosanus*	do	do	42	Italy		Fiori, 1881a.
1875	*Gordius villoti = G. aquaticus*	Mouth	do	7	do	Cerruti	Cerruti & Camerano, 1888a.
ca. 1897	*Paragordius tricuspidatus*	do	do	15	France	Dr. A. Boiteau	Blanchard, 1879d.
1900	*Parachordodes violaceus*	do	do	34	do		Topsent, 1900.
1901	*Parachordodes pustulosus*	Anus	Female	45	Italy	Prof. Luigi Griffini	Parona, 1901.
ante 1903	Undetermined				Maryland, U. S. A		Ward, 1903.
ante 1903	do				Michigan, U. S. A		Do.
1905	"? *Gordius alpestris*" = *Parachordodes alpestris.*	Mouth	Male	34	France		Guégnen, 1905.
18—	*Paragordius trifurcatus = varius*				Maine, U. S. A	Dr. Bowditch	Stiles, 1907.
ca. 1902	*Paragordius varius*	Anus	Female	13	Ontario, Canada	Dr. W. J. Stevenson	Do.
1904	*Paragordius varius*	Mouth			Illinois, U. S. A	Dr. J. L. Miller	Do.
1906	*Paragordius cinctus*				Lydenburg, Transvaal		Linstow, 1906.

[a] The short bibliographic citations are taken from Stiles & Hassall, Index-Catalogue of Medical and Veterinary Zoology, Bull. 39, U. S. Bureau of Animal Industry.

From this table we may classify the 18 cases as follows:

By species of parasite: *Gordius aquaticus*, 4 cases; *Paragordius varius*, 4 cases; *P. tricuspidatus*, 1 case; *P. cinctus*, 1 case; *Parachordodes tolosanus*, 3 cases; *P. pustulosus*, 1 case; *P. violaceus*, 1 case; *P. alpestris*, 1 case; not stated, 2 cases.

By countries: Europe—Austria, 1 case; France, 5 cases; Germany, 1 case; Italy, 4 cases. North America—6 cases (1 each for Canada, Illinois, Ohio, Maine, Maryland, and Michigan). Africa—Transvaal, 1 case.

By sex of patient: Male, 9 cases; female, 4 cases; not stated, 5 cases.

By age of patient: 0 to 10 years, 3 cases; 11 to 20 years, 2 cases; 21 to 30 years, 1 case; 31 to 40 years, 2 cases; 41 to 50 years, 2 cases; not stated, 8 cases (2 of which were apparently adults). Or—0 to 20 years, 5 cases; 21 to 40 years, 3 cases; 41 to 60 years, 2 cases; not stated, 8 cases. Kirtland's case ("a girl") can probably be counted under 21 years, thus giving 6 cases from 0–20.

The parasites escaped: By mouth in 9 cases; by anus, 5 cases; not stated, 4 cases.

Referring to the classification of the parasites it may be noted that the family *Gordiidæ* is divided by Camerano (1898g) into the four genera: *Chordodes*, *Parachordodes*, *Paragordius*, and *Gordius*, but Montgomery (1898) unites *Parachordodes* with *Gordius*. These genera may be distinguished by the following key, based upon the diagnoses given by Camerano.

KEY TO THE GENERA OF GORDIIDÆ.

(For forms known to occur in man in the United States, follow Roman type.)

1. *End of tail not lobed* 2
   End of tail bilobed 4
   End of tail trilobed .... *Paragordius varius* (female)
2. *Cloacal aperture ventro-median, with ventro-median groove extending from it to tip of tail* .... *Chordodes* (male)
   Cloacal aperture terminal, median; (female) 3
3. *External cuticular layer, in completely developed individuals, is devoid of areolar formations* .... *Gordius* (female)
   External cuticular layer with various kinds of areolar formations, and with hyaline clubshaped processes .... *Chordodes* (female)
4. *A postcloacal fold present in form of a lamina* .... *Gordius* (male)
   No postcloacal fold present 5
5. External cuticular layer presents areolar formations of a single kind, projecting very little and irregularly disposed; no interareolar refringent granules or tubercles .... *Paragordius* (male)
   External cuticular layer less complicated than in Chordodes; *with only one or two kinds of areolar formations; some of these are shallow and clear, and others a little more elevated and darker are around the opening of minute canals which traverse the cuticular layers; granules or refringent tubercules frequent among the areolæ* .... *Parachordodes* (male)

Genus GORDIUS Linnæus, 1758.

1758: *Gordius* Linnæus, 1758a, 644, 647 (*aquaticus* and *argillaceus*, Europe; *medinensis*).—Stiles & Hassall, 1905, 109 (*aquaticus* designed type).

Species GORDIUS AQUATICUS Linnæus, 1758.

1758: *Gordius aquaticus* Linnæus, 1758a, 647 (in argilla et aquis; Europe).

The following four cases of parasitism in man have been referred to this species:

CASE OF ALDROVANDUS, 1638a.—Aldrovandus does not appear to have seen any case himself, but he refers to a *Seta* or *Vitulus aquaticus*, which is usually interpreted as *Gordius aquaticus*, as follows:

"Such is the strength of this poison, if we credit the author of *De rerum natura*, that if taken in drink by man he is made faint and weak until he dies in excruciating pain. Albertus affirms the same thing, but that it is otherwise innocuous to the touch. Helvetius, the author of *Historia aquatilium*, also has seen persons dead of having drunk the *Vitulus aquaticus*. A certain man, he says, had pain around the præcordia soon after having drunk this worm; then a certain woman gave to him to drink a decoction of *Gentiana centaurium* in wine. He vomited and at once ejected the worm. If the *Vitulus aquaticus* is born in the belly of any one, the belly and stomach should be rubbed with a well-made mixture of equal parts of butter, wax, and oil. Calves, especially when full grown, swallow these worms sometimes, especially in the autumn, with vegetation, more rarely with water. There are those who believe that they [the worms] have their origin in Bruchus,[a] which does not seem likely to me; others [believe that they take their origin] from vegetation hanging down in water troughs where cattle drink.

"When swallowed they attach themselves around the throat and arteries [=windpipe?]: whence the cattle gradually waste away."

CASE OF SIEBOLD, 1854.—N. N., 22 years old, daughter of peasants in good circumstances in Schliersee, in Bavarian Mountains, of robust constitution, enjoyed continued good health. Menstruation began in 15th year, without difficulty, and never became deranged. In January, 1853, patient became ill, with the following symptoms: The girl, who was always well and red-cheeked, became pale; her disposition, otherwise gay, became changeable, then petulant, soon deeply melancholic, accompanied by an inexpressible fear of imaginary dangers, with considerable unrest and a trembling of the entire body; intense occipital headache, occasional asthmatic trouble, frequent fits of convulsive laughter, frequent sobbing and yawning for hours at a time, light horripilation, spasmodic unequal pulse. Gastric symptoms were entirely absent; there was neither nausea nor vomiting, nor loss of appetite. Patient emphatically denied having consciously eaten anything injurious.

The attending physician in Schiersee treated her for hysteria with nervines, which cured the trouble except for colicky pains in the abdomen. Nine months later the trouble reappeared; the same symptoms recurred, but with greater intensity; the trembling of the extremities, the feeling of fear, and the dyspnea became unbearable. As loss of appetite and tendency to vomit now developed, with heavy yellowish coating to the tongue, an emetic was administered. Upon the fourth vomiting the *Gordius* appeared, to the great terror of the patient. Immediately thereafter all nervous symptoms subsided, and the girl is at present as healthy and strong as formerly. Menstruation, which had not occurred since the first attack, also immediately became regular.

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[a] *Bruchus* Geoffr., 1764, is a coleopteron, but Harper's Latin Dictionary gives *Bruchus* as "a kind of locust without wings."

Siebold is of the opinion that the worm was not swallowed until just prior to the second attack, and that the irritation caused by its presence in the stomach caused a recurrence of the earlier hysterical symptoms. Blanchard (1890a, 89), on the other hand, thinks that the worm may have been swallowed as a larva and that it developed to the adult stage in the patient.

CASE OF PATRUBAN, 1875.—Patruban exhibited before the medical society in Vienna a specimen which he determined as *Gordius aquaticus*, sent to him by a colleague in Dalmatia, Austria, and said to have been passed in the stool of a Dalmatian boy 8 years old.

The assumption seemed justified that the worm was actually passed from the boy, because Patruban, upon expressing doubts upon this point and asking for further information, received word that a second such worm had been passed.

Opinion is expressed either that the boy swallowed a larval *Gordius*, which developed in his intestine to the adult worm, or that he swallowed a developed worm. Patruban believes the latter view more probable. Blanchard (1890a, 89), considering this case in connection with the case of Siebold, 1854, believes rather that the worm may have been swallowed as a larva and developed in the patient.

CASE OF CERRUTI & CAMERANO, 1888a–b.—In 1875, in Trabucco, Valle Superiore Mosso (Biellese), Italy, a boy of 7 years old manifested severe gastralgic pains, which confined him to bed for 24 hours, when Dr. Cerruti was called. The following day the child vomited abundant mucus with a female *Gordius villoti* [= *G. aquaticus*] 0.19 meter long, but without any trace of food. Thereupon the patient recovered.

The authors are of the opinion that this was a case of true parasitism; that the boy had become infected with the parasite in its microscopic, armed, stage; that this had developed in the wall of the stomach, then returned to the lumen of the stomach, when it caused the symptoms observed.

?CASE OF CAMERANO, 1888f, 397.—Camerano states that Professor Pavesi sent to him a female *Gordius villoti* [= *G. aquaticus*] found at Brescia, Italy, in December, 1874, on a dissecting table near a human cadaver. There is, however, no evidence that the worm came from the cadaver.

Doubtful species GORDIUS CHILENSIS E. Blanchard, 1849.

1849: *Gordius chilensis* E. Blanchard, 1849d, 109 (Valparaiso, Conception, etc., Chili).

ORIGINAL SPECIFIC DIAGNOSIS.—*Gordius:* "G. Gracilis, cinereofuscus, obscurus; capite nigro."

TYPE LOCALITY.—Valparaiso, Conception, etc., Chili.

Authors admit that this species is too incompletely described to be accepted at present. In the original account of the worm it is stated that the Indians fear it, believing that if introduced into the body it causes serious desease. No specific case seems, however, to be reported.

Genus PARAGORDIUS Camerano, 1897.

1897: *Paragordius* Camerano, 1897g, 368, 399–400 (*tricuspidatus*, *emeryi*, *stylosus*, *varius*).—Montgomery, 1898, 43 (type *varius*).

Two species of this genus have been reported as parasitic in man, namely, *P. varius* in North America and *P. tricuspidatus*, in Europe. As *P. varius* is the one of greater interest to American physicians, its description is given here in detail, based upon Montgomery's work.

Species PARAGORDIUS VARIUS (Leidy, 1851) Camerano, 1897.

(Figs. 35–55.)

1851: *Gordius varius* Leidy, 1851, 262 (U. S. A.)
1897: *Paragordius varius* (Leidy, 1851) Camerano, 1897g, 399, 402.

Specific diagnosis.—*Paragordius*: Dimensions. Length of largest male seen, 350 mm.; greatest diameter, 0.9 mm. Length of largest female, 290 mm.; greatest diameter (of a flattened individual), 2 mm. The males are more slender and average considerably shorter than the females.

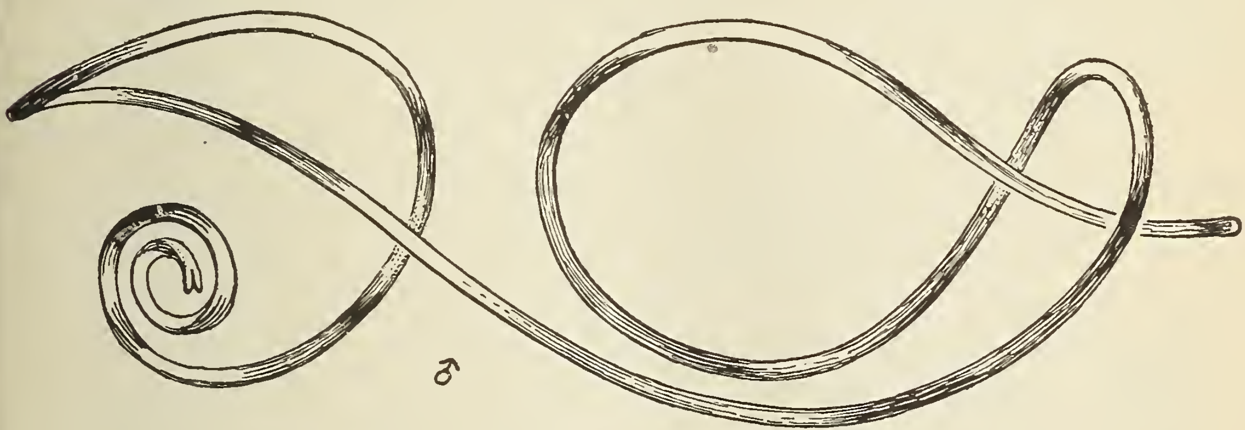

Fig. 35.—Male specimen of *Paragordius varius*, from man. × 4. Original.

Color: Color usually lighter in the females than in the males, varying from a light brown or yellowish to a dark brown (the larger individuals usually darker). The tip of the head is white or a pale brownish. Just behind there is a dark ring of color, usually rusty brown or even black, rarely pale. This ring is darkest at its anterior edge, and darker on the dorsal than on the ventral side of the body. At least a trace of this ring is to be seen on all mature specimens, though the intensity of its coloration is very variable.

Especial diagnostic characters: The trilobation of the posterior end of the female, the long and cylindrical tail lobes of the male, the oblique truncation of the head end, and the usually very dark-colored ring around the head, render this species very easy of identification.

Cuticle: On cross section an outer thin hyaline layer is seen, and an inner, much thicker fibrous layer. Embedded in the hyaline layer are small lozenge-shaped bodies, which stain more deeply than any other portion of the cuticle, and which correspond to the areolæ seen on surface views. The external surface of the hyaline layer of the cuticle is marked by short conoidal processes of the same structure as the hyaline matrix. These are not seen on surface views. On surface views the cuticle appears areolated. The areolæ are small, variable in size and form, and irregularly arranged. Sometimes they occur in groups, sometimes in interrupted longitudinal rows. Their arrangement varies both in different individuals, as well as on different portions of the same individual. The areoles are

irregularly polygonal in outline. In one female larger brown-colored areoles were present in addition to the smaller, lightly colored ones. The former were mainly arranged in the form of longitudinal ridges and were irregularly star-shaped in outline.

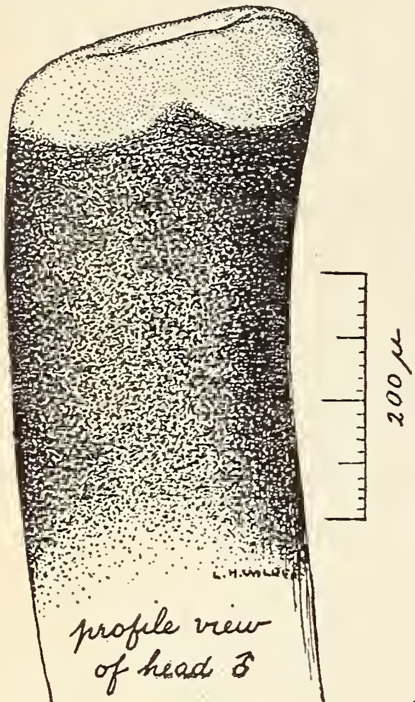

Fig. 36.

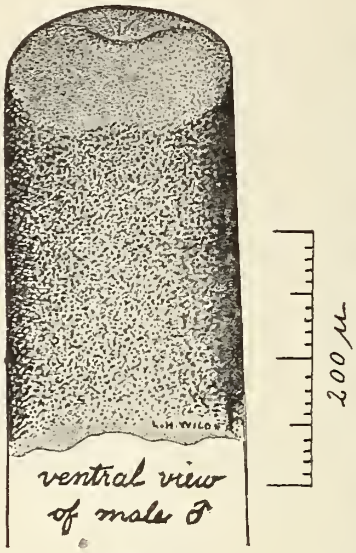

Fig. 37.

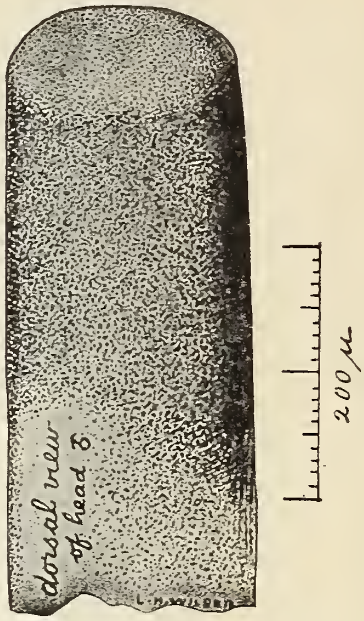

Fig. 38.

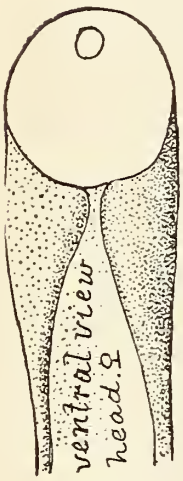

Fig. 39.

Fig. 40.

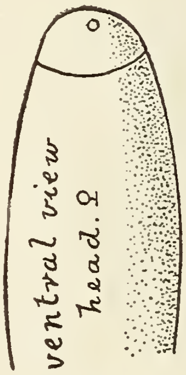

Fig. 41.

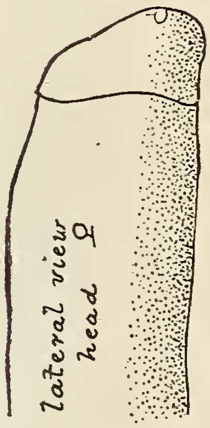

Fig. 42.

Figs. 36–38.—Three views of head of same. Enlarged. Original.

Figs. 39–42.—Four views of head of female *P. varius*. Enlarged. (After Montgomery, 1898, figs. 83a, 83b, 84–85.) (The head of my female specimen is not suitable to illustration, and on this account Montgomery's figures are taken, although they are not entirely in harmony with my specimen.)

Form of male: The anterior end as in the female, but the body more slender. The tail lobes are comparatively long and slender, cylindrical in shape, and obtusely rounded terminally. Small conical spicules occur on the medio-ventral surfaces of the anterior half of the lobes, and short hairs on their anterior surfaces. The elongate cloacal aperture lies in the medio-ventral line of the body, anterior to the tail lobes.

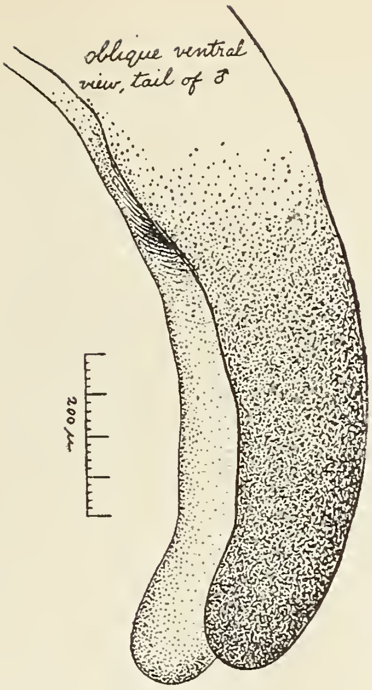

Fig. 44.

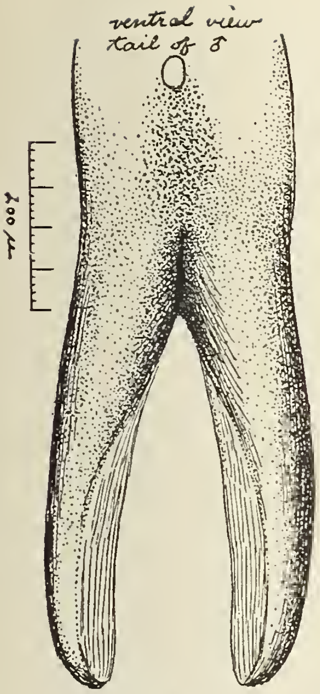

Fig. 43.

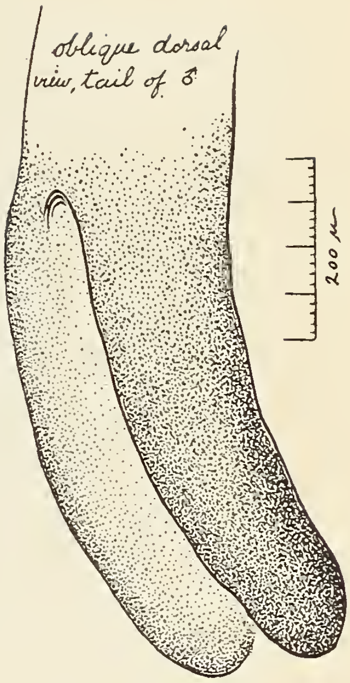

Fig. 45.

Fig. 46.

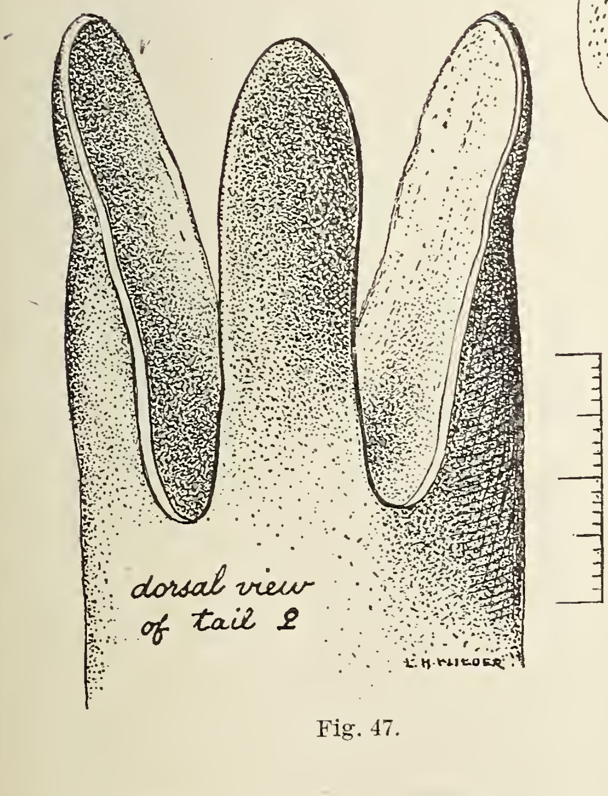

Fig. 47.

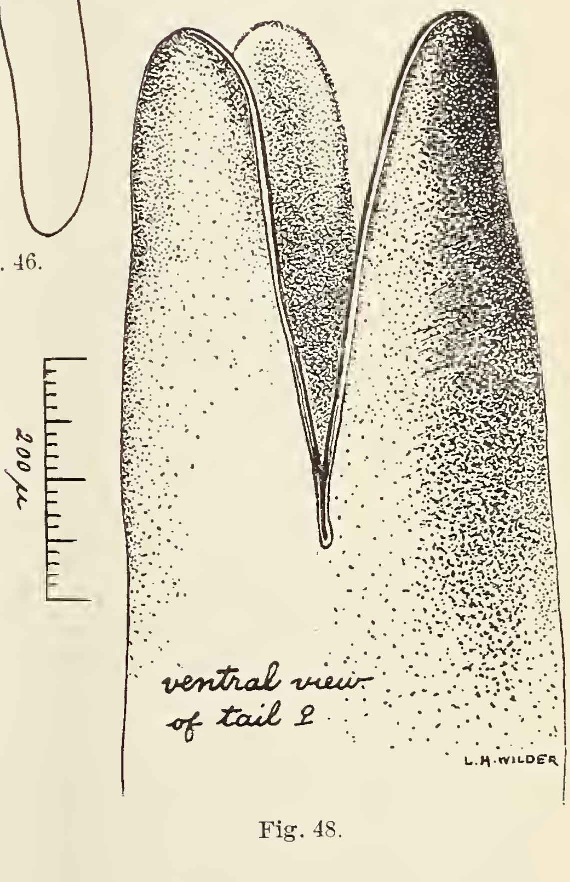

Fig. 48.

FIGS. 43–45.—Three views of tail of male. Enlarged. Original.
FIG. 46.—Ventral view of tail of male. Enlarged. (After Montgomery, 1898, fig. 87.)
FIGS. 47–48.—Dorsal and ventral views of tail of female. Enlarged. Original.

Form of the female: The anterior and posterior portions of the body are narrower than the middle, the decrease in diameter being very gradual; the anterior is narrower than the posterior end. The head end is obliquely truncated in such a way that the antero-ventral margin projects farther forward than does the antero-

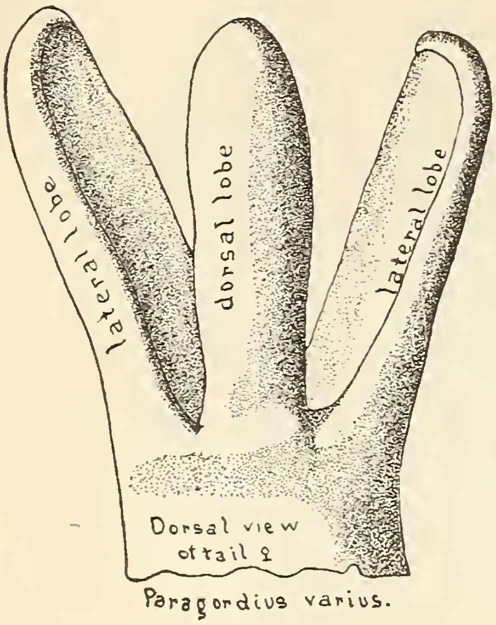

Fig. 49.

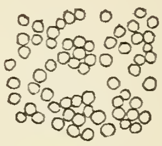

Fig. 54.

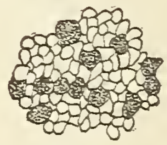

Fig. 53.

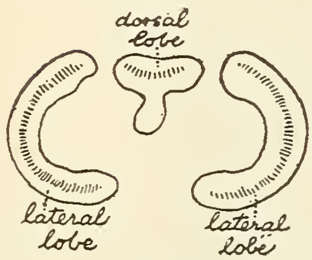

Fig. 50.

Fig. 52.

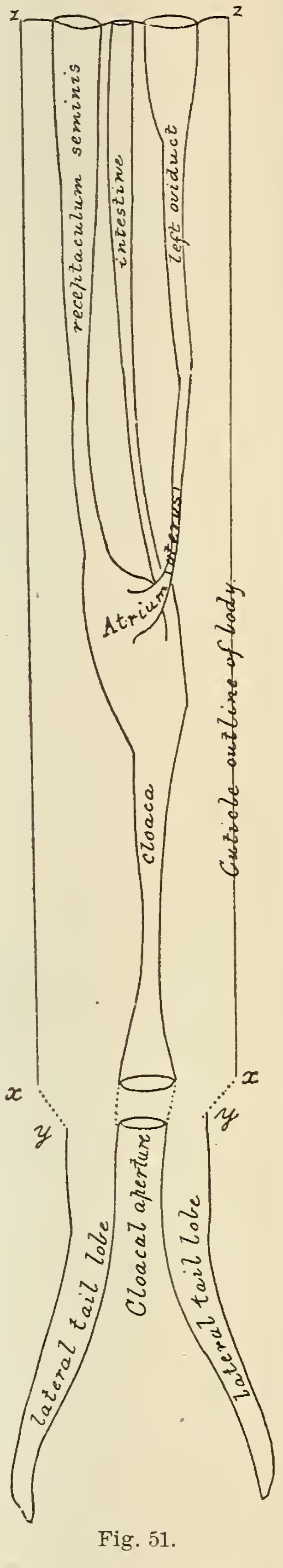

Fig. 51.

FIG. 49.—Dorsal view of tail of female. Enlarged. (After Montgomery, 1898, fig. 88.)

FIG. 50.—Cross section of same. Enlarged. (After Montgomery, 1898, fig. 80.)

FIG. 51.—Optical section of the caudal end of a female *P. varius*, showing anatomy; *x–y*, omitted portion, about 10 times the length of *x–z*. Enlarged. (Reduced from Montgomery, 1898, fig, 86.)

FIGS. 52–53.—Transverse section and surface view of cuticle of female. Enlarged. (After Montgomery, 1898, figs. 91 a-b.)

FIG. 54.—Surface view of cuticle of male. Enlarged. (After Montgomery, 1898, fig. 93.)

dorsal; this truncated plane, which forms the terminal aspect of the head, is very nearly flat. The mouth lies near the ventral edge of the truncated plane. The posterior end is trilobed, there being one dorso-median and two latero-ventral lobes; these lobes have no cuticular spines on their surface, and in the great majority of the numerous specimens examined are of equal length. Two specimens in the Harvard collection were exceptions to this equality in length; in one the dorsal lobe was slightly longer than the others, in the other slightly shorter. But the dorsal lobe is narrower than the others, and further differs from the latter in having an elevated median ridge on its ventral surface, so that on cross section it appears triradiate. The lateral lobes are crescent-shaped on cross section. The cloacal aperture, wholly hidden by these lobes, lies at their

base and between them, so that the cuticle and epidermis of the inner surface of the lobes are directly continuous with the cuticle and epithelium of the cloaca. The lobes may be either parallel or divergent, and hence are probably movable.

Comparisons: This species has the greatest affinity to *Paragordius tricuspidatus* (Dufour); but it differs from it in that there are spicules or spines upon the tail lobes of the female, and in that the dorsal is narrower than the lateral lobes; further, in *P. varius* the areoles of the cuticle are frequently arranged into rows or groups.

Geographic distribution.—North America (California, Canada, Illinois, Kansas, Maine, Maryland, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Virginia); Guatemala; and it has also been observed in Mexico, Peru and Bolivia. It appears to have a very extensive range, and it and *G. aquaticus robustus* are the most abundant forms in the northeastern portion of the United States.

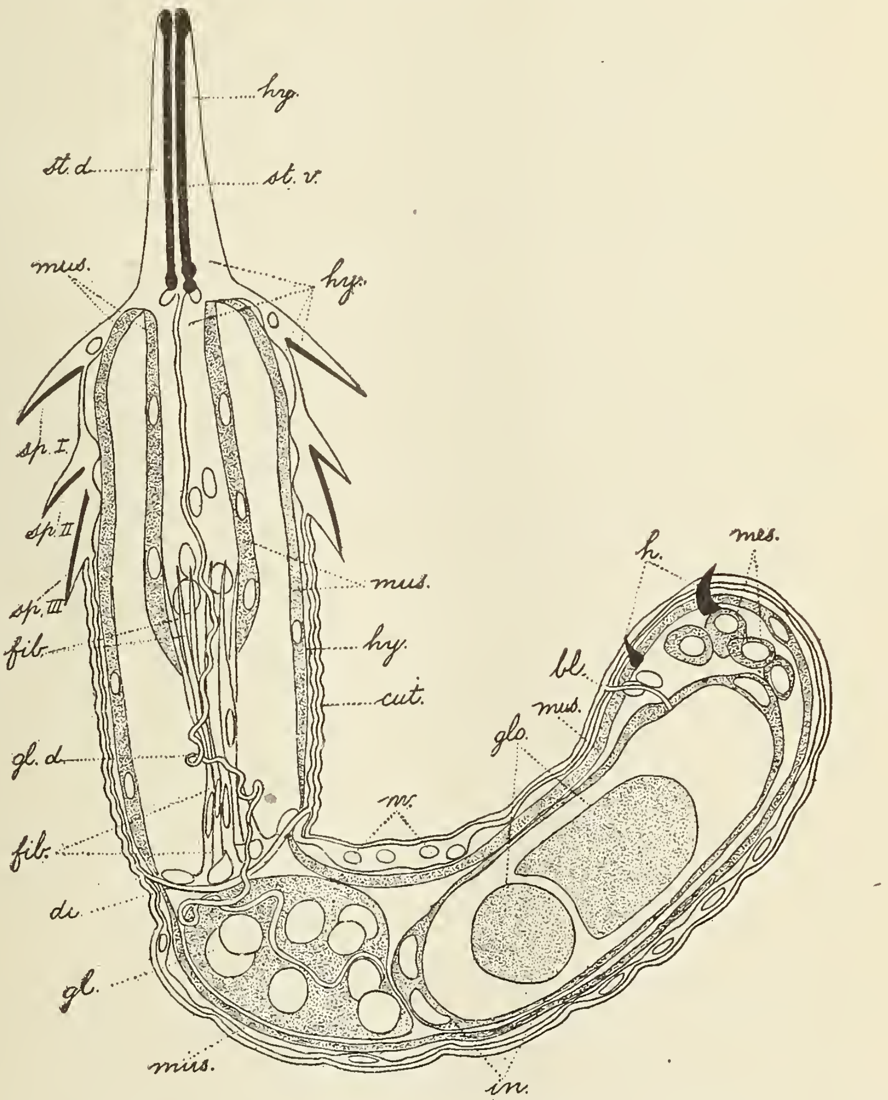

Fig. 55.—Larva of *Paragordius varius*, with extruded proboscis; *bl.*, blastopore; *cu.*, cuticle; *di.*, diaphragm; *fib.*, fiber cells; *gl.*, gland; *gl. d.*, gland duct; *glo.*, globules within intestine; *h.*, cuticular hooks; *hy.*, hypodermis; *in.*, intestine; *mes.*, mesenchym; *mus.*, musclulature; *nv.*, nervous thickening of hypodermis; *sp. 1* to *sp. 3*, spicules of rows 1 to 3; *st. d.*, dorsal stilets; *st. v.*, ventral stilets. (Reduced from Montgomery, 1904, fig. 36.)

The following four cases of infection with this worm have been found in North America:

Case of Kirtland, ante 1861.—I have been unable to find the original account of this case. Diesing (1861a, 604) refers to it simply by the words "Ohio ex ano puellæ expulsus (Kirtland)," and all later authors seem to report it on basis of this passage.

Unpublished Case of Bowditch.—In my host catalogue of parasites I have the following entry: "*Gordius trifurcatus-varius*, determined by —— ? ——, collected by Doctor Bowditch, host *Homo*, location —— ? ——, locality Saco, Maine, U. S. A., Cat. no. 111 Boston Soc. Nat. Hist." I have been unable to obtain any further details regarding this case.

New Case.—In February, 1902, Dr. W. G. MacCallum, of Johns Hopkins Hospital, forwarded to me for determination two worms which he had received from Dr. W. J. Stevenson, London, Ontario. The label stated that these specimens were passed in large quantities from the intestine of a girl 13 years old. Examination showed them to be *Paragordius varius*.

In a personal letter to me Doctor Stevenson states that the child exhibited no special symptoms. The worms were passed while the girl was sitting on a chamber, and the mother noticed them immediately. They seemed as stiff as wire, a fact which might give rise to the suspicion that they were dried and were in the chamber before the girl used it. One week later similar worms were again passed. The mother thought that the child had worms, because of her picking her nose and crying out during sleep. The child was accustomed to eating a great many apples. No further details are accessible to me.

New Case.—U. S. P. H. & M. H. S. specimen no. 9565 represents one male and one female specimen of *Paragordius varius*, forwarded to me by Dr. Joseph L. Miller, of Chicago, Ill., for determination. Doctor Miller wrote:

> I send you under separate cover a specimen which was given to me recently by a physician who reported that a patient had vomited it.

No further data regarding this case could be obtained.

Species PARAGORDIUS TRICUSPIDATUS (Dufour, 1828) Camerano, 1897.

1828: *Filaria tricuspidata* Dufour, 1828d, 222–224, pl. 12c (in *Gryllus burdigalensis;* France).

1856: *Gordius tricuspidatus* (Dufour, 1828) Meissner, 1856, 55.

1897: *Paragordius tricuspidatus* (Dufour, 1828) Camerano, 1897g, 399, 400.

The following case of parasitism has been ascribed to this species.

Case of R. Blanchard, 1897d.—Locality: Bassac (Charente), France. On May 1 a boy 15 years old, not in the habit of drinking wine, had just taken a full glass, when a few moments later he felt in his throat a peculiar tickling, similar to that occasioned by the presence of a hair. He inserted his fingers and encountered a sort of a thread, which he drew out. About 15 days before this occurrence the boy had taken a drink of water from a small brook; since then he had experienced a slight colic which disappeared after the expulsion of the worm. This worm was sent by Doctor Boiteau to Paris and was determined by Blanchard as *Gordius tricuspidatus*.

Species PARAGORDIUS CINCTUS Linstow, 1906.

1906: *Paragordius cinctus* Linstow, 1906, 245, fig. 11; Africa.

Linstow records this worm for man in Transvaal, Lydenburg, but gives no details regarding the case. The specimen from man was found in the collection of the Berlin Museum.

Genus PARACHORDODES Camerano, 1897.

1897: *Parachordodes* Camerano, 1897g, 368, 389–398 (*vejovskyi*, *raphaelis*, etc.).—Stiles & Hassall, 1905, 127 (*tolosanus* as type).

Four species of this genus have been recorded as parasitic in man.

Species PARACHORDODES TOLOSANUS (Dujardin, 1842) Camerano, 1897.

1842: *Gordius tolosanus* Dujardin, 1842, 146 (probably France).
1897: *Parachordodes tolosanus* (Dujardin, 1842) Camerano, 1897g, 389 bis, 398 (Europe).

Case of Degland, 1823.—The original account of this case is not accessible to me, but the following statements are taken from various authors, chiefly from Blanchard, 1890a, 90:

Following the administration of an emetic, a boy of 8 years of age vomited a worm, 14 to 16 cm. in length, which Degland referred to "*Gordius aquaticus.*" Villot, 1884, 88, however, believes that it was a *Parachordodes tolosanus.* From Blanchard's abstract of this case, it is not quite clear to me whether he considers the case identical with that reported by Cloquet (see below) or whether he simply considers the parasites as specifically identical. Not being able to obtain Degland's paper, I am unable to settle this point definitely, but from the fact that Blanchard gives the age of Degland's patient as 8 years, while Cloquet's patient does not appear to have been so young, I give the two cases here as distinct.

Case of Cloquet, 1822a–b.—M. Raymond Pontier, a physician in Uzerches, sent the parasite in question to Varéliaud, Paris, who gave it to Cloquet for determination. The latter described it as a new species, *Ophiostoma pouterii* 1822a, 99, and *Ophiostoma ponterii* 1822b, 32. This is classified by Blanchard and by Railliet as a synonym of *Gordius tolosanus.*

The worm was vomited by a farmer near Uzerches; he had been subject to attacks of epilepsy for some years, but these ceased permanently as soon as the worm was expelled.

The worm was cylindrical, 9 inches long by half a line in its greatest diameter; brown in color, finely annullated with clearer circles; its "mouth" [=tail] was "bilabiate," the under "lip" being longer than the upper.

Case of Fiori, 1881a.—In April, 1881, Fiori, the attending physician at the Torino jail, administered 12 grams of thymic acid to a male prisoner 42 years old who was affected with uncinariasis. In the washings of the first stool passed a long, brown, filiform, actively motile worm was found in addition to the hook worms. This long worm was determined by Dr. Daniele Rosa as a male *Gordius tolosanus* Duj. seu *G. subbifurcus* Siebold. The symptoms noticed were in harmony with uncinariasis and could not be definitely attributed to the *Gordius.*

? Case of Camerano, 1888f, 397.—Camerano relates that Professor Pavesi sent to him a female *Gordius tolosanus* found at Brescia, Italy, December, 1874, on a dissecting table near a human cadaver. There is, however, no evidence that the worm came from the cadaver.

Species PARACHORDODES PUSTULOSUS (Baird, 1853) Camerano, 1897.

1853: *Gordius pustulosus* Baird, 1853a, 37; 1853b, 20, pl. 30, fig. 4 (in *Blaps obtusa;* London, England).
1897: *Parachordodes pustulosus* (Baird, 1853) Camerano, 1897g, 389 bis, 396–397 (Europe; China).

One case of infection has been referred to this species.

Case of Parona, 1901.—In 1901 a woman 45 years of age, in Lodi, Italy, passed a worm per anum; the symptoms had not been severe; there was a frequent and annoying sensation of a moving body in the abdomen, with rectal and anal pruritus, and an obstinate catarrhal discharge from the anus. These symptoms lasted about three months, but suddenly ceased after the discharge of the worm.

Species of PARACHORDODES VIOLACEUS (Baird, 1853) Camerano, 1897.

1853: *Gordius violaceus* Baird, 1853a, 36; 1853b, 20, pl. 30, fig. 3 (in *Carabus violaceus;* Bermickshire).
1897: *Parachordodes violaceus* (Baird, 1853) Camerano, 1897g, 289 bis, 392–393 (Europe; Transcaucasia).

One case of infection has been referred to this species.

Case of Topsent, 1900, 86–91.—Topsent presented before the Société scientifique et médicale de l'Ouest, Rennes, France, a living male specimen of *Gordius violaceus*, which had been vomited, February 22, 1900, by a farmer, 34 years old, near Fougères. Patient had experienced gastric trouble for about a month; for 8 days prior to expelling the worm he had experienced an uneasiness in his throat, sensation of a lump which changed position, and a tickling which produced a continual desire to vomit. Upon expelling the worm there was entire relief.

Species PARACHORDODES ALPESTRIS (Villot, 1884) Camerano, 1897.

1884: *Gordius alpestris* Villot (1884), 44–45.
1897: *Parachordodes alpestris* (Villot, 1884) Camerano, 1897g, 389 bis, 393–394.

One case of infection with this species has recently been reported.

Case of Guéguen, 1905, 398–400.—A laborer, 34 years old, at Chabanais (Charante), France, was accustomed to drinking at an exhausting pump used for draining the yards. Early in July, after having drunken of this stagnant water, coming both from springs and rains, he was seized with colic which lasted two days and then ceased for about two months. Then loss of appetite developed, together with vomiting after meals; this condition of malaise lasted five days and during the last two days was accompanied by colic. On the fifth day, after a light meal, together with a drink of pure water, vomiting occurred, resulting in the expulsion of a large female *Chordodes*, 34.4 cm. long, ? *Gordius alpestris* Villot [= *Parachordodes alpestris*]. Guéguen believes the worm must have been swallowed when young, and that it developed to its present size in the man's intestine.

Genus and species undetermined.

CASES OF WARD, 1903.—In referring to Kirtland's case, Ward states that "two other unpublished cases have recently been communicated to me from Michigan and Maryland."

In reply to a personal letter Ward has informed me that—

"I remember the cases reasonably distinctly and I am sure of the fact that I was unable to secure the specimens, so that the species must remain undetermined. I am also under the impression that the practitioners could give no information in regard to the cases."

MEDICAL SIGNIFICANCE OF HORSEHAIR WORMS.—Reference has already been made to the popular view in certain localities to the effect that these worms, if swallowed, produce very serious and even fatal results. The cases summarized above do not, however, bear out this view, but they support the opinion usually held by physicians and zoologists that horsehair worms are not dangerous. In fact, with the exception of Cloquet's and Siebold's cases, the symptoms seem to have been rather slight, or, at least, not severe.

In this connection it is interesting to note that Bacounin (1790a, 34) fed large horsehair worms to dogs, cats, and birds without serious effects; then he swallowed two such worms himself. He states that he felt a kind of malaise, which soon disappeared. After this he fed six such worms to a boy without any unfavorable results.

KEY TO NORTH AMERICAN SPECIES OF GORDIIDÆ.—Probably almost any species of this family may occur in man. The following key, slightly rearranged, from a paper by Montgomery (1899), will enable the reader to determine the North American species:

1. Caudal extremity trilobed .... *Paragordius varius* (female), p. 59
   Caudal extremity bilobed, spirally enrolled (*Paragordius* and *Gordius* males) 3
   Caudal extremity not lobed (*Chordodes* male and female, *Gordius* female) 2
2. Caudal extremity spirally inrolled, narrower than the preceding portion of body and with a depression or groove on its ventral surface (*Chordodes* male) 10
   Caudal extremity not spirally inrolled, not narrower than the preceding portion of body (*Chordodes* and *Gordius* females) 12
3. A sharp V-shaped ridge behind cloacal aperture 4
   No sharp V-shaped ridge behind cloacal aperture 6

PARAGORDIUS and GORDIUS males.

4. Cuticle marked with large white spots; male .... *Gordius aquaticus* (Linnæus)
   Cuticle not marked with white spots 5
5. A parabolic line of hairs on caudal lobes; male.
   Gordius aquaticus difficilis Montgomery
   No line of hairs on caudal lobes; male .... *Gordius aquaticus robustus* Leidy
6. A longitudinal line of hairs on each side of cloacal aperture; male.
   Gordius lineatus Leidy
   No line of hairs on each side of cloacal aperture 7
7. Head end obliquely truncated; male .... *Paragoridus varius* (Leidy), p. 59
   Head not obliquely truncated 8

8. No conical spicules behind cloacal aperture; caudal lobes cylindrical; male.
Gordius platycephalus Montgomery
Conical spicules behind cloacal aperature.......................................9
9. Caudal lobes short, thick, nearly conical; male.
Gordius densareolatus Montgomery
Caudal lobes nearly cylindrical; male........*Gordius longareolatus* Montgomery

CHORDODES male.

10. Cuticular areoles longer than high; on or between them are small circular pits; male................................*Chordodes occidentalis* Montgomery
Cuticular areolæ higher than long.. 11
11. Spines on summits of the highest arioles (papillæ); male.
Chordodes puerilis Montgomery
No spines on summits of the highest papillæ; male.
Chordodes morgani Montgomery

CHORDODES and GORDIUS females.

12. Caudal end not noticeably enlarged .... *Gordius* (females), 13
Caudal end swollen, somewhat knob-shaped, slightly constricted off.
Chordodes (females), 19

GORDIUS females.

13. Elevated cuticular areoles on entire surface of body........................ 14
Without elevated cuticular areolæ on entire surface........................ 17
14. With paired dark stripes in median lines; females...*Gordius leidyi* Montgomery
No dark stripes in median lines.. 15
15. Areoles elongated in long axis, and well separated from one another; female.
Gordius longareolatus Montgomery
Areoles not elongated in long axis of body................................. 16
16. Areoles closely apposed, tending to produce longitudinal ridges; female.
Gordius lineatus Leidy
Areoles more or less confluent, tending to produce transverse rows; head usually cylindrical; female ....*Gordius densareolatus* Montgomery
Areoles usually separated, interareolar groups of fine hairs, head usually flattened; female ....*Gordius platycephalus* Montgomery
17. Cuticular areoles only at ends of body; female.
Gordius aquaticus difficilis Montgomery
Cuticular areoles entirely absent 18
18. Cuticle marked with white spots; female ....*Gordius aquaticus* Linnæus
Cuticle without white spots; female ....*Gordius aquaticus robustus* Leidy

CHORDODES females.

19. Cuticular areoles longer than high; on or between them circular pits; female.
Chordodes occidentalis Montgomery
Cuticular areoles higher than long; female..................................20
20. Spines on summits of highest areoles; female....*Chordodes puerilis* Montgomery
No spines on summits of highest areoles; female.
Chordodes morgani Monticelli

INDEX TO ZOOLOGICAL NAMES.

O

TREASURY DEPARTMENT.
Public Health and Marine-Hospital Service of the United States.
WALTER WYMAN, Surgeon-General.

HYGIENIC LABORATORY.—BULLETIN No. 35.
M. J. ROSENAU, Director.
FEBRUARY, 1907.

REPORT

ON

THE ORIGIN AND PREVALENCE OF TYPHOID FEVER IN THE DISTRICT OF COLUMBIA.

BY

M. J. ROSENAU, L. L. LUMSDEN,
and JOSEPH H. KASTLE.

(Including articles contributed by Ch. Wardell Stiles,
Joseph Goldberger, and A. M. Stimson.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

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United States Public Health and Marine-Hospital Service.

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Report on the Origin and Prevalence of Typhoid Fever in the District of Columbia.

INTRODUCTION.

The prevalence of typhoid fever in Washington has long been a matter of concern to the inhabitants of the District of Columbia. The transient visitor to Washington, seeing only the broad boulevards, handsome structures, and the general air of beauty and cleanliness of the city, obtains the impression of a particularly healthful city. It is often a matter of surprise, therefore, to learn that Washington has a comparatively high death rate, especially from typhoid fever, which has generally been considered a "filth disease."

Why Washington should pay such a high tax to typhoid fever has been the subject of frequent investigation. All such studies have, as a rule, been focused on the water supply, although such conditions as pollution of the soil, infection through milk, oysters, and other articles of food, the importation of cases, the contamination of shallow wells, and more recently the danger of communicating the disease through direct contact, and indirectly by means of flies and other agencies, have also received attention.

The Potomac water has long been regarded as polluted, both by the large majority of the medical profession and by the public at large. The muddy character of the water has doubtless exaggerated its unwholesome qualities in the public mind. From time to time, therefore, engineering projects to improve the quality of the water, such as subsiding basins, have been conceived and carried out. These improvements, however, did not materially affect either the turbidity of the water or the typhoid-fever situation. Congress, therefore, provided for a further purification of the water supply by means of slow sand filtration, appropriating for this purpose the sum of $3,468,405. The filters were constructed under supervision of officers of the Engineering Corps, United States Army, and, so far as general principles of construction are concerned, they embody the best conceptions that modern sanitary engineers have to offer. Advantage was taken of the experience in slow sand filtration gained in actual practice in this country and abroad.

The work was rapidly pushed to completion, so that by November, 1905, the city was supplied with filtered water. During the follow-

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Manuscript submitted Feb. 16, 1907.

ing winter and early spring months there was comparatively little typhoid fever in the District of Columbia; but suddenly, in July, 1906, there occurred such a great increase in the number of cases that the disease was properly regarded as prevailing in epidemic form. This corresponds with the history of the disease in many previous years.

The recurrence of the disease under the greatly improved conditions of the water supply was a matter of keen disappointment both to the medical profession and to the general public, inasmuch as assurance had been given, and indeed it had been confidently expected, that the introduction of sand filtration would largely diminish the disease, as it had done in Lawrence, Lowell, Albany, London and Hamburg, and other American and European cities. The health officer of the District, Dr. William C. Woodward, found himself confronted with a difficult and unusual situation, and at his instance the Commissioners of the District of Columbia requested the Surgeon-General of the Public Health and Marine-Hospital Service to cooperate with the health officer in making a study of this subject, as may be seen by the following letter:

Executive Office, Commissioners of the District of Columbia,
Washington, June 21, 1906.

Dear Sir: The number of reported cases of typhoid fever in the city of Washington has increased instead of diminished within the year, notwithstanding the opening of the filtration plant and the official tests showing that it is in successful operation. The health department of the District of Columbia has been unable thus far to account for the general prevalence of typhoid fever, as shown by the reports, in view of the official statement as to the working of the filtration plant and the efficiency of the milk-supply inspection, and especially in view of the fact that the cases appear in uniform numbers throughout the community and seem to have no particular foci.

As the facilities of the health department for making a complete investigation of the causes of typhoid fever are limited, I have the honor, on behalf of the Commissioners, to ask for the cooperation of your Department in order that this important and, at present, mysterious matter may have a thorough and comprehensive treatment in the interests of the health of the national capital. Besides such assistance as your Department can give in the general investigation, I have to ask that you will cause an early and simultaneous bacteriological examination of the water from each of the public pumps, which are also a possible source of danger. The health department has not the means to make such an analysis, although from time to time it has made a chemical analysis of all the public pumps, so that each is inspected at least once a year and closed if found to be contaminated. As a possible source of typhoid fever germs, the public pumps, of which there are over ninety in constant use by large numbers of people—transients as well as residents—in their neighborhoods, seem to require our special attention.

The Commissioners will be grateful for the cooperation of your Department and for the suggestions of any additional measures which they may take to safeguard the health of the community in this relation.

Sincerely, yours,

H. B. F. Macfarland,
President Board of Commissioners of the District of Columbia.

Surg. Gen. Walter Wyman,
Public Health and Marine-Hospital Service.

In accordance with this request the Surgeon-General detailed the undersigned board of officers to convene July 2, 1906, for the purpose of making an investigation of the origin and prevalence of typhoid fever in the District of Columbia.

The work soon proved to be of such complexity that it was found necessary to bring to our aid the following officers of the Laboratory, some of whom were specially detailed to the Laboratory by the Surgeon-General for this purpose, namely, Passed Assistant Surgeon John F. Anderson, Passed Assistant Surgeon W. W. King, Passed Assistant Surgeon Joseph Goldberger, Passed Assistant Surgeon Baylis H. Earle, Assistant Surgeon Arthur M. Stimson, Assistant Surgeon Norman Roberts, and Ch. Wardell Stiles, Ph. D. In fact, during the past summer almost the entire force of the Hygienic Laboratory concentrated its energies on this problem.

These investigations have included a sanitary survey of the Potomac watershed; an exhaustive epidemiological study of the 866 cases of the disease occurring in the District of Columbia between June 1 and October 31, 1906; daily chemical and bacteriological examinations of the water supply; a special study of the pumps, wells, and springs in the District, and also of bottled waters sold in Washington; an inspection of the dairies and laboratory examinations of the milk supply; an inspection of the ice factories; chemical and bacteriological examinations of a number of samples of ice, as well as the water from which the ice is made; and the making of blood cultures, diazo and Widal reactions for practicing physicians in the District. The question of shellfish, salads, fruits, and other raw food products in relation to the disease has also been studied. Further, special attention has been directed to the communicability of the disease from person to person, by direct or indirect contact. The relation of privies and sewers to wells has also been investigated, and the question of flies and other insects as carriers of infection has received attention. The bathing beach and public markets have been inspected from time to time. Finally, in the division of zoology many specimens of feces have been examined in order to determine the possible relation of animal parasites to the disease.

The results reached in this investigation, together with the conclusions and recommendations arrived at by the board, are given in the general summary of this report. In addition to the summarized statement, detailed reports, giving the data upon which the conclusions and recommendations are based, are also submitted.

On account of the difficulties and magnitude of the problem it was the desire of the Surgeon-General, as well as of the board, to continue these investigations over an entire year. However, in view of existing conditions it seems desirable to publish our data and conclusions in

their present form, together with such recommendations as are possible from a limited inquiry into so large a subject.

With the facilities of the Hygienic Laboratory at our disposal it was hoped to advance the study of typhoid fever by experimental investigations upon the life history of the typhoid bacillus outside the body. The press of other matters, however, prevented us from taking up this phase of the subject. The work will be continued, especially with a view of determining the presence or absence of the typhoid bacillus in the Potomac River water, in well waters, in milk, and other foods, and also to determine what percentage of the population may act as bacillus-carriers.

Respectfully submitted.

M. J. Rosenau,
Director Hygienic Laboratory, Chairman,
L. L. Lumsden,
Passed Assistant Surgeon,
Joseph H. Kastle,
Chief Division of Chemistry, Recorder,
United States Public Health and Marine Hospital Service.

ACKNOWLEDGMENTS.

In compliance with the instructions of the Surgeon-General this investigation into the causes of typhoid fever in the District of Columbia was carried out in cooperation with the health department of the District. We especially desire to express our appreciation of the valuable assistance and hearty cooperation of Dr. William C. Woodward, the health officer of the District, and his assistants. From the official records Doctor Woodward gave us numerous transcripts and caused special compilations to be made. He further acquainted us with important factors influencing local conditions, and in other ways helped us with suggestions growing out of his long experience with public health matters in the District.

We desire to express our obligation to the officers and employees of the Washington filter plant, especially to Captain Cosby, Mr. Hardy, and Mr. Longley for much valuable information relative to the filtration of the Potomac water supply and for placing at our disposal the results of their bacteriological determinations and chemical analyses.

We are indebted to Dr. W. A. White, superintendent of the Government Hospital for the Insane, for material assistance and for information relative to typhoid fever in that institution.

To Mr. M. O. Leighton, chief of the hydrographic division of the United States Geological Survey, we are indebted for information and for the use of a manuscript entitled "The Potomac River Basin, Water-Supply Paper No. 192," by Horatio M. Parker, and also for a map of the Potomac watershed, upon which our special notations have been made.

SUMMARY AND RECOMMENDATIONS.

The prevalence of typhoid fever in the District of Columbia is due to several causes. During the period covered by our investigation we found that about 10 per cent of the cases were attributable to infected milk; about 15 per cent of the cases were imported; about 6 per cent of the cases were traceable to "contact." This accounts for about 30 per cent of the 866 cases studied.

EPIDEMIOLOGICAL STUDIES.

Eight hundred and sixty-six cases of typhoid fever reported between June 1 and November 1, 1906, were investigated.

SEX.

The number of cases was relatively somewhat higher in males than in females.

RACE.

The morbidity rate was a trifle higher and the mortality rate was much higher in the colored than in the white race.

The following is a statement of the typhoid death rates per 100,000 according to race for the last twelve years:

Year.	Total.	White.	Colored.
1895	73.8	64.3	94.1
1896	51.0	46.8	60.4
1897	43.6	37.5	56.6
1898	64.3	50.2	95.3
1899	67.2	47.3	111.0
1900	74.1	64.0	96.7
1901	56.4	42.8	87.1
1902	74.0	71.5	79.7
1903	45.0	38.1	60.8
1904	43.8	35.5	63.4
1905	43.9	40.0	53.3
1906	49.3	35.4	83.1
Average	57.2	47.78	78.45

AGE.

The bulk of the cases occurred between the ages of 10 and 30 years. A conspicuously large number of cases occurred in children under the age of 15 years. The prevalence of the disease among

children makes it probable that many cases are not recognized, as typhoid is especially mild and irregular in children. The prevalence of the disease among children may have an important bearing upon the subject of the spread of the disease by direct and indirect contact.

IMPORTED CASES.

One hundred and twenty-nine of the 866 cases studied, or about 15 per cent, contracted their infection outside of the District of Columbia. Sixty-six of these imported cases were taken directly to hospitals and 15 more were taken to hospitals after a stay of a few days at private houses. The fact that this large number was treated in the hospitals shows that the chances of dissemination of the infection by the imported cases was correspondingly diminished.

SEASONAL PREVALENCE.

There was a sudden rise in the number of cases early in July, reaching its maximum early in August, and then a marked falling off about the middle of August, which decline continued through September. It is a striking fact that the marked rise occurred with the advent of the hot weather, but the disease declined while the weather continued hot and moist.

The seasonal prevalence for this year is very similar to that for previous years. In other words, typhoid fever is largely a summer disease in Washington. In some years, however, the disease continued throughout the late fall. (See chart No. 4.)

The secondary rise, which occurred in October, 1906, was largely a milk outbreak. (See chart No. 1.)

GEOGRAPHICAL DISTRIBUTION.

During the period covered by our investigation the disease was quite uniformly distributed throughout the inhabited portions of the District of Columbia. This widespread and uniform distribution suggests some common factor as one of the principal means of disseminating the infection. In no instance was anything approaching a local focus noted. There was no unusual grouping of cases about shallow wells, in crowded and insanitary courts and alleys, or in districts where privies are numerous. It is interesting that there were no such local outbreaks in these localities where the conditions seemed favorable for the spread of the disease by direct contact and flies.

It is interesting to note that at the Government Hospital for the Insane, with a population of about 3,000, most of them of a susceptible age, there were no cases of typhoid fever in 1906, while around the institution the disease prevailed in about its normal distribution. For details as to isolation, water and milk supply of this institution, see page 298.

SANITARY CONDITIONS OF RESIDENCES.

The disease certainly did not prevail to any unusual extent among persons living under poor sanitary conditions. On the contrary, it was more prevalent among persons living in residences of the better class. Most of the cases occurred in houses connected with the city sewerage system and in which there were water-closets. Only 72 of the cases occurred in houses with privies.

While no special grouping of cases occurred in the neighborhoods where privies are numerous, we commend the efforts of the health officer in abolishing the privies in the District as fast as means allow.

SCREENS AND FLIES.

Two hundred and sixty cases occurred among persons living in houses that were well screened, 390 in houses that were not screened, 94 in houses that were screened in part, and 3 in houses where the screens were not noted.

The relation to flies is as follows: Eleven cases in houses with practically no flies; 287 cases in houses with few flies; 367 cases in houses with a moderate number of flies; 40 cases in houses with many flies; 39 cases in houses with very many flies; 3 cases in houses where the number of flies was not noted.

These figures indicate that the disease did not prevail to any special extent among persons living in houses where flies were abundant. This, however, does not take into consideration the part which may have been played by flies in the spread of the infection through the contamination of food and by other means, outside of residences where cases occurred.

OTHER VERMIN.

Our studies indicate no special relation between the number of mosquitoes, ants, roaches, bedbugs, rats, or mice at residences and the prevalence of the disease.

DOMESTIC ANIMALS.

It is well known that certain infections are communicated from domestic animals to man. Such a relation has never been seriously considered for typhoid fever. However, we give the following facts:

Cases occurring in houses where there were—		Cases occurring in houses where there were—	
Dogs	197	Goats	2
Cats	266	Chickens	133
Guinea pigs	8	Ducks	3
Rabbits	7	Turkeys	1
Pet mice	1	Canary birds	32
Horses	36	Mocking birds	1
Cows	7	Parrots	1
Hogs	5		

FRUITS AND VEGETABLES.

On account of the difficulties in obtaining accurate information regarding the sources of fruits and vegetables eaten raw, no definite statement can be made concerning the relation of such food to the disease. However, our impression is that they played little or no part in the spread of the infection.

SHELLFISH AND FRESH-WATER FISH.

The disease prevails in Washington to the greatest extent at the season of the year when comparatively few shellfish are eaten. Further, the great majority of cases gave a history of having eaten no shellfish during the thirty days prior to onset of illness. The same applies to fresh-water fish. The following table gives the data in regard to the eating of shellfish and fresh-water fish by the cases:

	Yes.	No.	Not stated.
Oysters (30 days prior to illness)	60	655	32
Clams (30 days prior to illness)	64	647	36
Lobsters (30 days prior to illness)	8	708	31
Crabs (30 days prior to illness)	190	516	41
Fresh-water fish (30 days prior to illness)	205	504	38

We may therefore safely conclude that such articles of diet played no appreciable part in spreading the infection.

OCCUPATION.

No special relation between occupation and the disease can be made out. It is interesting to note that during the period studied by us the number of cases was relatively somewhat high among housekeepers, bartenders, draymen, hackmen and teamsters, messenger boys, newsboys, steam railway men, stenographers, machinists, and persons attending school. Three cases occurred among dairymen.

MILK.

We found that the 747 cases considered as having contracted their infection in the District of Columbia gave the following history in regard to the use of milk within thirty days prior to illness:

As a beverage, 488; in fruits and cereals, but not as a beverage, 90; in hot tea or coffee only, 50; as ice cream only, 65; none, 40; not stated, 14. Eighty-five of these cases were attributed to the use of infected milk, and of these, 6 were attributed to the use of infected ice cream.

ICE.

Five hundred and ninety-eight cases used ice in beverages; 125 used no ice in food or beverages; 24 cases gave no data.

WATER.

Of the 747 cases, 721, or 96.54 per cent, gave a definite history of having used unboiled Potomac water, supplied through the city system, as the sole, principal, or occasional source of water for drinking purposes during thirty days prior to onset of illness.

Of the 26 cases occurring among persons who did not give a definite history of having drunk unboiled tap water, 2 were attributed to infection by contact, 7 to infection by milk, 1 to infection by ice cream, and 5 may have contracted their infection outside of the District of Columbia. Seventeen drank unboiled milk supplied by the dealers of the District.

The following table gives the source of water used for drinking purposes during the thirty days preceding the onset of illness, by the 747 cases studied:

Raw tap water:[a]	
Solely	443
Principally	196
Occasionally	73
Occasionally (?)	12
Boiled tap water:	
Solely	2
Principally	47
Occasionally	15
Filtered tap water:	
Solely	1
Principally	10
Occasionally	3
Occasionally (?)	1
Public pumps:	
Solely	1
Principally	3
Occasionally	94
Occasionally (?)	31
Bottled water:	
Solely	1
Principally	7
Occasionally	13
Private wells or springs in District of Columbia:	
Solely	4
Principally	36
Occasionally	33
Various sources out of District of Columbia:	
Principally	0
Occasionally	69

[a] By raw tap water is meant water as it comes from the taps and neither boiled nor filtered after it leaves the tap. The difference of 9 in the number of cases which used "raw" tap water and the number which used unboiled tap water is explained by the fact that all the tap water drunk by these 9 cases was filtered through some kind of a house filter. In none of these instances was the filtration considered efficient.

Melted ice:

Solely	1
Principally	1

SODA WATER.

Three hundred and ten drank soda water within thirty days prior to illness, 392 drank no soda water within thirty days prior to illness, 45 not stated.

CONTACTS.

Thirty-two of the 747 cases studied gave a history of direct and intimate contact with patients in the febrile stage of the disease. Nine gave a history of slight or occasional association with patients in the febrile stage. Twelve had free and intimate association with cases suspected of being typhoid fever, but which were not reported as such. In 21 cases the conveyance of the infection by persons or flies was strongly suggested. Therefore a certain percentage (about 6 per cent) of the cases studied may reasonably be attributed to contact.

No satisfactory information could be obtained upon the question of direct or indirect contact with persons recently (within three to four months) convalescent from the disease or with chronic bacillus-carriers.

That some cases contracted their infection in this manner seems probable, and therefore it may be argued that a larger percentage than above indicated were infected by contact.

PROPHYLAXIS.

Of the 866 cases, 374, or 43.18 per cent, were treated in hospitals. This naturally diminished the chances of dissemination of the infection. As a further factor bearing on this same point, 119 of the cases treated at private homes were cared for by trained nurses.

Of the 492 cases treated at home, the use of disinfectants in stools and urine was found to be efficient for 145 cases, inefficient for 286 cases, of doubtful efficiency for 51 cases, not stated for 10 cases.

Of other measures taken to prevent the spread of the infection, such as treatment of clothing, bedding, and dishes used by the patient, and care of the hands of the persons attending the patients, the precautions carried out were: Fairly efficient, 212 cases; inefficient, 270 cases; not stated, 10 cases.

The destruction of the infection as it leaves the body is the most important measure to prevent the spread of typhoid fever. In our opinion it is the duty of the attending physician to see that these measures are effectively carried out. It is evident from the above figures that this important prophylactic measure is not carried out as it should be in the District of Columbia. If this condition of affairs

can not be corrected voluntarily, then we should recommend its enforcement by legislative enactments.

To sum up the epidemiological findings:

Eight hundred and sixty-six cases studied.

About 129 cases, or 15 per cent, contracted their infection outside of the District of Columbia.

About 85 cases, or 10 per cent, were attributed to infected milk or ice cream.

About 54 cases, or 6 per cent, were attributed to infection by contact.

Leaving about 598 cases, or 68 per cent, unaccounted for.

THE MILK PROBLEM.

Three separate milk outbreaks occurred in Washington between June and November, 1906. Eighty-five of the 866 cases of typhoid fever studied during this time were attributed to the use of infected milk. The source of the infection was traced to cases of the disease at the city dairy or at the dairy farm. Quite probably other cases contracted their infection from milk, but the number of such cases must remain problematical. In at least two instances employees at the dairy lived in houses in which cases of typhoid were being treated, and in other ways the relation between the disease, the infection and the milk was found to be very close.

Our inspections have shown that despite the regulations of the health department many dairymen deliver milk in bottles to houses in which there is typhoid fever. Returned bottles are not disinfected as they should be, either with steam or boiling water. The washing of the bottles is frequently imperfect, and after washing they are exposed mouth upward to dust, flies, and other sources of contamination. It was found in most instances that the cans and bottles were washed with tap water.

A few of the dairies have excellent machines for washing and scalding bottles, but sometimes neglect to heat the water, thus reducing the efficiency and one of the objects of the machine.

The paper caps or stoppers are not handled with sufficient care. They are exposed to dust, flies, etc., and are often handled with unclean fingers.

Remembering that milk bottles are frequently used by householders for other purposes than to hold milk, that they are often taken into the sick room, and that they run many risks of contamination with infection—not only of typhoid but other diseases—it would not be unreasonable to require all dairymen to disinfect bottles as a routine practice.

It is easy to understand how a bottle or a limited number of bottles of milk may become infected and be the cause of spreading the disease.

It should be remembered that the typhoid bacillus grows and multiplies in warm milk with great rapidity and that the milk may be teeming with these organisms without appreciably changing its appearance, odor, or taste. The danger is, therefore, hidden and insidious.

Another source of danger is the small corner grocery where milk is retailed. At such places often as little as 1 or 2 cents' worth of milk is sold at a time, from pint or quart bottles.

In several instances, we found a close association between the family life of the patient and the business. The same hands that nurse the sick often purvey the milk. The patient is treated in a room adjoining the store. Flies swarm in and out. The chances of spreading the infection in this and many other ways must be great.

The small retailers, while subject to inspection, are immune from the sanitary restrictions of the health department. This state of affairs evidently needs legislative correction.

The milk supplied the citizens of the District is, for the most part, too old, too dirty, and too warm. Milk is not kept cold, especially in transit from the farm to the city dairy, and on the delivery wagons from the dairy to the householder. Of 172 samples tested during the warm months, only 16 were 10° C. (50° F.) or under. The average temperature of the 172 samples was 16.5° C. (61.7° F.). The dangers of warm milk in which bacteria and their toxic products develop to a dangerous degree are now well recognized. Of the 172 samples of milk tested only 29 contained less than 500,000 bacteria per cubic centimeter. The average of all the samples examined was 22,134,289 per cubic centimeter. Hence the great bulk of the milk sold in Washington during the summer months would have been considered adulterated and condemned in New York and prohibited from sale in Boston, on account of the temperature or the number of bacteria.

Practically all of the samples examined contained gas-fermenting organisms, indicating contamination with cow-dung and other extraneous matter. Most of the samples studied contained more visible foreign matter (dirt) than has a place in clean milk.

So far as the city dairies themselves were concerned many defects were found. For instance, the location of many dairies is pernicious, in that they abut upon unkempt alleys and are in the neighborhood of squalid, insanitary settlements. The stables in the rear of practically all the dairies visited provide breeding places for swarms of flies and are a source of foul odors.

Flies are attracted by the milk and are abundant in nearly all the dairies. In some instances the water-closets are too near to the milk. Only one of the dairies visited was properly screened. In most instances no intelligent warfare is waged against the flies. At one dairy the milk from various sources is mixed in a large vat resembling

a bath tub. This vat was open at the time of the inspection, and from 10 to 15 flies were being mixed up with the milk.

At most of the dairies the hands of the employees who come into contact with the milk were dirty and their clothing not changed or covered with a clean apron. Employees who handle milk should be required to wear clean laundered clothing, or at least a clean apron or gown. Their hands should be thoroughly washed before beginning work.

The milk passes through too many hands and is exposed too many times before it reaches the consumer. The general rule with the milk business in the District of Columbia appears to be that the farmer sends his milk either directly to the railroad station or to a neighboring collecting depot; from this point it passes into the care of the railroads and is shipped to town without ice. The milk is received at the city railroad depot and carted to the city dairies, where it is sometimes mixed, aerated, separated, reassembled, cooled, and filtered before it is bottled. It would evidently be much better if the milk could be cooled and bottled at once on the farm or at the near-by collecting depots, thereby avoiding much handling and consequent chances of contamination.

The milk is kept too long before reaching the consumer; the loss of about a day being common at most of the dairies.

While the present outbreak of typhoid fever is by no means wholly attributable to milk, the wonder is, judging from our observations of the milk business in the District of Columbia, that more sickness and disease is not spread through this medium.

ICE.

Ice can not be a frequent vehicle by which the infection of typhoid is spread owing to the fact that the great majority of bacteria are killed in the process of freezing.

Our studies indicate that ice plays little, if any, part in spreading the infection of typhoid in the District of Columbia. The possibility, however, of typhoid infection being occasionally present in manufactured ice sold in Washington is indicated by the unclean methods used at the factories. Urine and excrement are carried on the shoes of the workmen to the tops of the cans or tanks, from there dropping into the freezing water. This is confirmed by our bacteriological examinations, which disclose a greater number of organisms in the ice than in the water from which the ice is made. The contrary should be the case.

"Can" ice in the District is made mostly from distilled water and should be safe. "Plate" and "block" ice is made largely from tap water, and if not subsequently contaminated should also be reasonably free from injurious pollution.

It is recommended that the manufacture of ice and the traffic in natural ice in the District of Columbia should be placed under close sanitary control of the local health authorities, and that bacteriological and chemical facilities should be provided for the frequent examination and control of this product.

TYPHOID BACILLUS-CARRIERS.

It is now well known that some persons in good health discharge typhoid bacilli in live and virulent form, in their urine and feces for periods of months and years. Such persons are known as "bacillus-carriers" (bacillen-träger).

The fact that persons in average health may harbor the cholera vibrio in the intestinal tract or the diphtheria bacillus in the throat has been known and its importance in preventive medicine appreciated for some years; but it is only recently that a similar relationship in the case of typhoid fever has actually been confirmed. It must be plain that bacillus carriers may be particularly active agents in spreading the infection throughout a community in view of their undiminished activities and the total ignorance of the fact that they are foci of infection.

The question of typhoid bacillus carriers complicates the epidemiological studies, inasmuch as cases contracting their infection by this means are very difficult to trace.

TYPHOID FEVER A "CONTAGIOUS" DISEASE.

Our studies confirm the trend of modern opinion that typhoid fever may be communicated directly from man to man. This emphasizes the importance of isolation and disinfection in this disease.

THE SUPPOSED RÔLE OF INTESTINAL WORMS AS INOCULATING AGENTS IN TYPHOID FEVER.

In view of the theory advanced by Guiart that intestinal worms, especially whipworms, commonly play an inoculating rôle in typhoid fever, somewhat similar to the rôle played by fleas in bubonic plague, 200 of the present typhoid cases (selected at random) were examined for intestinal worms. Statistically considered, the infections found correspond approximately to the infections which would be expected among these patients independent of their typhoid condition. Only 15 cases (7.5 per cent) showed a total of 16 infections (8 infections per hundred), of which 14 cases (7 per cent) showed whipworms. This represents only 1.3 infections (0.65 infections per hundred persons) over what was expected in general helminthiasis, and an increase of only 1.32 per cent over what was expected in whipworm infections. Considering the very wet season, and especially in view of the negative

findings in 185 (92.5 per cent) of the patients, these slight increases can hardly be considered of importance.

The general conclusion is therefore reached that, contrary to Guiart's view, neither whipworms nor other intestinal worms play any essential rôle as inoculating agents in this disease.

THE WELL WATERS.

The waters of the shallow wells have frequently been regarded as a means of conveying the infection of typhoid fever, and, as there are 63 shallow wells in the District of Columbia used by the public, we have made a particular study of this phase of the subject.

The waters of 87 public wells are used for drinking purposes in the District of Columbia. Twenty-four of these wells are "deep" and 63 are "shallow." As will be seen from our report, the water of the deep wells has been found to be of excellent quality, both chemically and bacteriologically. Some of these so-called "artesian" wells are practically sterile, and no evidence was found of fermenting organisms. On the other hand, both the bacteriological and chemical examinations indicate quite a different condition in the case of the shallow wells. Of the 63 shallow wells now used by the public 31 show indications of sewage pollution, 29 are waters of suspicious character, and only 3 show no evidence of pollution.

Our studies developed, further, that the water of many of the shallow wells varied widely from time to time, both in chemical composition and in the number and character of the bacteria present. This in itself is a dangerous indication from a sanitary standpoint, showing an intermittent source of surface contamination or sewage pollution.

It is also evident from a study of our data that there is a relation between the proximity and number of privies and the bacteriological and chemical findings of the well waters. It was found, further, that most of the wells with broken pumps and leaky platforms, permitting surface contamination, often disclosed this condition by the laboratory analyses. On the other hand, our epidemiological studies revealed no special grouping of typhoid cases about any particular well, and no definite relation could be discovered between the use of any particular well water and the occurrence of typhoid cases. This is no guarantee that some of these shallow wells have not been infected in past years and will not again become so in the future. The infection of a shallow well is usually temporary.

It is evident that a densely inhabited area with miles of sewers, some of them doubtless broken or leaky, and with almost 4,000 privies must produce a more or less polluted condition of the soil, rendering the ground water unfit for drinking purposes. On general sanitary principles alone shallow wells and privies have been elimi-

nated from all large cities having an abundant water supply and sewerage system. We unhesitatingly subscribe to this view and believe that the shallow wells in the District of Columbia should be condemned—a conviction that is abundantly confirmed by the results of our chemical and bacteriological examinations.

From the fact that 31 of the 63 shallow wells show indications of sewage pollution and 29 are suspicious we feel justified in recommending the permanent closing of all the shallow wells in the District of Columbia, and if for any reason any of those now regarded as suspicious should be continued in use, laboratory facilities should be afforded the health officer of the District to watch them closely and authority granted him to close immediately any such well upon the first indication of sewage pollution, or, as an alternative, close the shallow wells and sink deep wells in their place.

THE TABLE WATERS.

There is on sale in the city of Washington a great variety of "mineral" waters, both foreign and domestic. One dealer publishes a list of more than sixty kinds. The inspection was confined to those table waters collected from sources in or near the city or bottled here. Studies were made of the source and mode of purveyance of these waters and samples were taken for chemical and bacteriological examination with a view of discovering any injurious contamination.

Several instances of fraudulent labeling were discovered.

The claims of some dealers as to the sterilization of their water bottles could not be substantiated.

No relation between the use of bottled waters and the spread of typhoid fever is apparent in the District of Columbia.

THE POTOMAC DRAINAGE BASIN.

The Potomac River at Great Falls drains an area of about 11,400 square miles. The population of this area was estimated to be, in 1900, about 500,000, or 44 per square mile. The velocity of flow of the Potomac is extremely variable. It has been estimated that it takes from four to seven days for the water to travel from Cumberland to Great Falls, a distance of about 176 miles. Typhoid fever prevails to a greater or less degree in every part of the drainage basin. No data for an accurate determination of its degree or seasonal prevalence are obtainable; such data as were obtained indicate that its seasonal prevalence closely corresponds to that of Washington.

The waters of the Potomac are directly polluted by sewage at numerous points. This direct pollution is contributed by not more than 45,000, or 9 per cent of the total population of the watershed. Of this pollution about 80 per cent enters the river at points 176 miles or more from the intake of the Washington Aqueduct at Great

Falls; about 15 per cent enters it at points between 50 and 175 miles above Great Falls, and 5 per cent, contributed by about 2,200 of the population, enters at points between 19 and 50 miles above the intake.

Practically no direct pollution of the Potomac takes place within 19 miles of the intake, but as this portion of the watershed is inhabited, the possibility and danger of direct pollution of the river within this section can not be ignored.

The great bulk of the pollution of the Potomac being distant undergoes more or less natural purification, and in addition becomes very greatly diluted before it reaches the intake at Great Falls.

We recommend the enforcement of streams-pollution acts looking to the removal of overhanging privies and other sources of contamination on the Potomac and its tributaries, especially from Harpers Ferry to the intake.

THE SAND FILTERS.

In our opinion the sand filtration plant represents a high degree of engineering skill and intelligent management. The water is greatly improved both bacteriologically and chemically by the storage and filtration, as indicated by the figures on page 27 *et seq.*

It was known before the filters were installed that slow sand filtration alone could not at all times render the Potomac water clear; experience has shown this to be correct. Some other treatment, such as increased storage capacity, preliminary filtration or the occasional use of a coagulant during periods of high turbidity, is necessary in order to obtain a clear effluent at all times.

It is reasonable to expect that continued experience and further experiments with the special problem in hand will result in still further improvements in the filtered water, especially so far as turbidity is concerned.

MUD IN THE WATER PIPES.

The suggestion has been advanced that the large amount of mud contained in the pipes of the water system retains the typhoid infection and thence it is distributed throughout the city. From our knowledge of the viability of the typhoid bacillus we think this extremely unlikely, and a few experiments with the mud in question confirms this opinion.

BACTERIOLOGY OF THE POTOMAC RIVER WATER.

The following is a summary of our bacteriological examinations of the raw and filtered waters:

Summary of bacteriological examinations of raw and filtered waters of the reservoirs.

[July 30 to September 27, 1906.]

	Dalecarlia.		Georgetown.	Washington.	Filtered water.
	Inlet.	Outlet.			
Number of specimens examined	9	12	11	19	16
Average number of bacteria per cubic centimeter	526	381	306	235	36
Number of specimens examined	15	15	15	24	21
Percentage showing the B. coli in 1 cc	40.0	40.0	33.3	16.6	4.7
Percentage showing the B. coli in 10 cc	26.6	40.0	40.0	41.6	9.5
Total percentages showing B. coli	66.6	80.0	73.3	58.2	14.2

The following is a summary of our bacteriological examinations of tap water:

Summary of the bacteriological examination of tap water.

[July 16 to October 16, 1906.]

Number of specimens examined 131
Average number of bacteria per cubic centimeter 64.0
Average number of bacteria per cubic centimeter, excluding the 9 specimens containing over 100 organisms per cubic centimeter 36.0
Percentage in which *B. coli* was found 17.5
 Percentage in which *B. coli* was found in 10 cc 15.2
 Percentage in which *B. coli* was found in 1 cc 2.2

JULY.

Average number of bacteria per cubic centimeter, 30 specimens 74.1
Average number of bacteria per cubic centimeter, excluding the 3 specimens containing over 100 organisms per cubic centimeter 39.3
Percentage in which *B. coli* was found 33.3
 Percentage in which *B. coli* was found in 10 cc 30.0
 Percentage in which *B. coli* was found in 1 cc 3.3

AUGUST.

Average number of bacteria per cubic centimeter, 30 specimens 60.7
Average number of bacteria per cubic centimeter, excluding the 3 specimens containing over 100 organisms per cubic centimeter 40.3
Percentage in which *B. coli* was found 26.6
 Percentage in which *B. coli* was found in 10 cc 23.3
 Percentage in which *B. coli* was found in 1 cc 3.3

SEPTEMBER.

Average number of bacteria per cubic centimeter, 41 specimens	83.4
Average number of bacteria per cubic centimeter, excluding the 3 specimens containing over 100 organisms per cubic centimeter	40.5
Percentage in which *B. coli* was found	12.2
Percentage in which *B. coli* was found in 10 cc	9.7
Percentage in which *B. coli* was found in 1 cc	2.4

(NOTE.—Specimen No. 326 is not included in these figures.)

OCTOBER 1–16, INCLUSIVE.

Average number of bacteria per cubic centimeter, 30 specimens, none over 100	21.0
Percentage in which *B. coli* was found	0.0

Our findings, based upon a limited number of examinations, show 93.1 per cent bacterial improvement resulting from storage and filtration.

Of the 15 samples of raw water examined by us 66.6 per cent contained the colon bacillus.

Of the 21 samples from the filtered water reservoir 14.2 per cent showed the colon bacillus.

Of the 131 samples of tap water examined 17.5 per cent showed the colon bacillus.

The following are the results obtained at the laboratory of the filtration plant for the same period (August and September), based upon examinations made daily (except Sunday):

Period.	Dalecarlia.		Georgetown reservoir.	Washington City reservoir.	Filtered water reservoir.
	Inlet.	Outlet.			
August (number of bacteria per cc.)	8,658	1,077	1,231	188	14
September (number of bacteria per cc.)	422	245	136	133	14

The percentage reduction, according to these figures, is 99.9 per cent. For the period from February to October, 1906, the reduction was 99.4 per cent.

The following bacteriological results upon the colon bacillus obtained in the laboratory of the filtration plant are given for comparison:

	Quantity.	July 16 to Oct. 16.	
		Number positive.	Per cent positive.
	cc.		
Dalecarlia inlet	10.0	10	19
	1.0	9	17
	.1	17	33
Dalecarlia outlet	10.0	13	25
	1.0	11	21
	.1	11	21
Georgetown	10.0	11	21
	1.0	12	23
	.1	8	16
Washington City reservoir	10.0	14	19
	1.0	13	17
	.1	0	0
Filtered water reservoir	10.0	3	4
	1.0	1	1
Tap water	10.0	6	6
	1.0	5	4

CHEMICAL ANALYSES OF THE POTOMAC WATER SUPPLY.

The following are the results of the chemical analyses of the water of the several reservoirs and storage basin for the period covered by our investigation, viz, from July 30 to September 27, 1906, together with a table showing the improvement in parts per million and in per cent of the water of the Potomac River accomplished by subsidence and filtration:

Averages of 14 analyses of the waters of the reservoirs and storage basin, made at intervals of 3–4 days to 1 week from July 30 to September 27, 1906.

Name of reservoir.	Turbidity.[a]	Total solids.			Chlorine.	Ammonia.	
		Total residue.	Mineral matter.	Volatile matter.		Free.	Albuminoid.
Dalecarlia inlet	221.0	203	156	47.1	2.6	0.024	0.161
Dalecarlia outlet	99.0	163	115	48.0	2.61	.027	.131
Georgetown	55.2	160	111	49.0	2.61	.022	.117
Washington City (unfiltered)	46.3	141	100	41.0	2.47	.017	.096
Storage basin (filtered)	4.6	127	88	39.0	2.53	.015	.054

[a] Average of all readings made.

Averages of 14 analyses of the waters of the reservoirs and storage basin, made at intervals of 3–4 days to 1 week from July 30 to September 27, 1906—Continued.

Name of reservoir.	Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
Dalecarlia inlet	0.0031	0.61	7.44	89.6	4.1
Dalecarlia outlet	.0051	.57	7.62	92.4	3.4
Georgetown	.0065	.60	7.44	90.0	3.3
Washington City (unfiltered)	.0056	.61	7.60	90.0	3.0
Storage basin (filtered)	.0003	.67	5.87	71.4	2.0

Chemical improvement of Potomac water as the result of subsidence and filtration.

[Compiled from analyses made in the division of chemistry of the Hygienic Laboratory, covering a period of 11 weeks, from July 16 to September 28, 1906.]

	Turbidity.	Total solids.			Chlorine.	Ammonia.	
		Total residue.	Mineral matter.	Volatile matter.		Free.	Albuminoid.
Dalecarlia inlet	221.0	203.0	156.0	47.1	2.6	0.024	0.161
Storage basin	4.6	127.0	88.0	39.0	2.53	.015	.054
Improvement in parts per million	216.4	76.0	68.0	8.1	.07	.009	.107
Improvement in per cent	97.9	37.4	43.5	17.1	2.7	37.5	66.0

	Nitrites.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
Dalecarlia inlet	0.0031	7.44	89.6	4.1
Storage basin	.0003	5.87	71.4	2.0
Improvement in parts per million	.0028			2.1
Improvement in per cent	90.0			51.0

Dissolved oxygen consumed in oxidation, 21 per cent.

THE RELATION OF THE POTOMAC RIVER WATER TO TYPHOID FEVER.

The typhoid fever bacillus has never been isolated from the Potomac River water. We therefore have no direct evidence to prove or disprove that some of the infection may or may not be water borne. We must, then, satisfy ourselves for the present with certain indirect evidence bearing upon this important question.

Despite the improvement in the water, due to storage, sedimentation, and filtration, no appreciable change in the typhoid situation is apparent.

Water-borne epidemics, due to concentrated and quickly transferred infection, may occur at any time of the year, particularly in the spring and late fall. Such epidemics are generally characterized by sudden onset and sharp decline. Little is known of the characteristics of typhoid-fever outbreaks resulting from water containing greatly diluted and slowly transferred infection.

The presence of typhoid bacilli in great dilution and perhaps attenuation may not have the power of directly causing the disease in persons drinking such water. Water, however, containing an occasional typhoid bacillus may infect a community in such a way that large numbers of persons become bacillus-carriers. With the advent of the hot weather many such persons may be stricken with typhoid fever, just as the depressing influence of the heat is known to determine the onset of diarrheal diseases and other intestinal infections. In other words, the presence of the typhoid bacillus in the intestinal tract has not always the power of causing typhoid fever. We must reckon with our host. The dilute and attenuated infection in the water may sow the seed; for the production of the disease we must have susceptibility, and this susceptibility may be largely brought about by the diminished resistance caused by the summer heat.[a]

We are totally ignorant of the number of bacilli ordinarily necessary to produce the disease. It is reasonable to assume that water containing the typhoid bacillus in great dilution may sometimes directly cause the disease in highly susceptible individuals. On this assumption we would expect, in a community in which the great majority of the population drink such water, the cases to be widely scattered and a very small proportion of the people to have the disease. Further, we must consider that the occasional and perhaps attenuated typhoid bacillus in water may increase in danger and virulence by contaminating milk and other beverages or foods that are favorable media for its rapid growth and multiplication.

In favor of the view that the Potomac water plays an important part in the dissemination of typhoid fever in Washington, we have the following:

The uniform distribution of the disease throughout the city, indicating a common medium, such as water.

The great majority (96.5 per cent) of the cases studied gave a history of having drunk unboiled tap water within thirty days prior to the onset of the disease.

The majority of the population drink unboiled tap water; and so, if this water contains typhoid bacilli in dilute suspension, the chances of infection reaching the susceptible individuals are favored. During the year 1906 one person in about every 300 of the population of the District of Columbia had typhoid fever and during the season of greatest prevalence the cases which occurred during each half-monthly period were widely scattered over the District. (See maps Nos. 1, 2, 3, 4, 5, and 6.)

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[a] This same hypothesis also applies to any other means by which the infection is conveyed, such as direct and indirect contact.

Colon bacilli are found in the water. These organisms are usually taken as an indication of sewage pollution. Sixty-six and six tenths per cent of the 15 samples of the river water examined contained the colon bacillus; 14.3 per cent of the 21 samples of filtered water, and 17.5 per cent of the 131 samples of tap water examined contained the colon bacillus in 1 and 10 cc.

It is evident, therefore, that a certain number of the colon bacilli in the raw water pass the storage reservoirs and sand filters. Therefore it seems reasonable to assume that a certain number of typhoid bacilli, when present in the raw water, may also pass into the tap water.

The Potomac River at numerous points along its course receives the sewage of a number of thousands of persons.

Some of the typhoid fever in the District in former years was apparently traced to the Potomac River water. For example, the outbreak in Cumberland, Md. (December, 1889, to April, 1890), was followed by an increase in typhoid fever in the early spring in Washington. A sudden decrease in the Washington death rate followed the installation of the Dalecarlia reservoir in 1895. (See p. 224.)

The typhoid death rate for 1906—that is, since the filtration of the water—was 49.3 per 100,000. This is a much higher typhoid death rate than is usually observed for large American and European cities having water supplies of undoubted purity.

Considering that there were due to contact and to infected milk twice as many cases as we were able to attribute fairly definitely to these causes, there still remains about half of the cases unaccounted for. If the water is not a factor in the spread of the infection, then it would appear that some unknown agent or agents for the dissemination of the infection must be peculiarly active in Washington.

In favor of the view that the Potomac water plays little, if any, rôle in the dissemination of typhoid fever in Washington, we have the following:

The improvement in the water supply was not followed by an improvement in the typhoid fever situation.

Typhoid fever may diffuse itself broadcast throughout a community using water free from suspicion—the so-called "prosodemic" type of Sedgwick and Winslow.[a]

The great majority of the population of Washington drink unboiled tap water, which may be considered as diminishing the value of the suggestion that the tap water is a common factor.

The colon bacillus is not the typhoid bacillus, and the sanitary significance of the presence of colon bacilli in amounts less than 1cc.

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[a] Sedgwick, W. T., and Winslow, C. E. A. Statistical Studies on the Seasonal Prevalence of Typhoid Fever, etc. Memoirs of the Amer. Acad. of Arts and Sciences, xii, p. 568. 1902.

in river water has perhaps been exaggerated. It must be borne in mind that many colon bacilli in a surface water, such as the Potomac, derive their origin from the intestinal tracts of animals other than man.

The filtered river waters of Lawrence, Albany, Philadelphia, etc., also contain a few colon bacilli, and the total number of bacteria here compare favorably with the number found in the effluents of the above-mentioned cities. Sand filtration of the above river waters, giving a somewhat similar bacterial effluent, as judged by the total number of bacteria and the colon bacilli, has been followed by a reduction in the typhoid death rate.

According to the researches of Kinyoun and Sprague in 1897, the tap water contained the greatest number of colon bacilli during September and October, whereas the disease during that year prevailed to the greatest extent during the preceding months.

It seems that, so far as the incomplete records are obtainable, typhoid fever prevails to a great extent at the same season in Washington and over the entire watershed. This indicates that the causes, whatever they may be, act simultaneously along the entire course of the river.

While it is true that the Potomac receives the sewage directly of many thousands of persons, much of this pollution is distant and greatly diluted. Self-purification takes place to such an extent that the water at the intake averages comparatively few bacteria per cubic centimeter the year round compared with other grossly polluted streams and may be considered of fair sanitary quality compared with many such streams used for drinking purposes.

It is probably true that in former years some of the typhoid fever in Washington was due to infection in the river water; but in view of the improvement of the water by storage, sedimentation, and filtration, it would seem reasonable to suppose that the danger of infection from the water may have been largely eliminated.

Typhoid fever in Washington is mainly a summer disease. There is a great and sudden increase in the number of cases with the advent of hot weather. This seasonal prevalence repeats itself year after year with great regularity. If the bulk of the infection were water-borne, it would seem that we would have more marked irregularities of the curve from year to year, as is seen in other communities where much of the disease is plainly due to highly infected water.

The seasonal prevalence of typhoid in Washington corresponds to that of Boston, New York, Baltimore, and other cities in which the water is believed not to play much part.

If we attribute the bulk of infection to imported cases, contacts and milk, then it would not be necessary to consider that some un-

known agent or agents causing the dissemination of the disease must be peculiarly active in Washington.

The high death rate from typhoid fever in the District of Columbia is partly accounted for by the fact that the disease is more fatal in the colored than in the white race. About one-third (90,000) of the population are colored. During the period 1895 to 1906 the relative average death rates were—

	Per 100,000.
White	47.8
Colored	78.2
Total	57.9

The death rate for 1906, that is, since the filtration of the water, was—

	Per 100,000.
White	35.4
Colored	83.1
Total	49.3

A typhoid death rate of about 20 to 25 per 100,000 in the larger cities of Massachusetts has been attributed to causes other than infected water (prosodemic typhoid). North Adams, with a population of about 25,000, has a death rate of 39 per 100,000.

Winnipeg, with artesian water of exceptional purity as its principal supply, has a death rate more than double that of Washington. Typhoid fever in Winnipeg is also a summer disease.

Communities have had pronounced epidemics of typhoid fever in which the water is reported to have played no appreciable part. The same is true of army encampments.

So far as typhoid fever is concerned, it seems that Washington may be classed with the southern cities, where this disease is either unusually prevalent or unusually virulent, as indicated by the high death rates.

Death rates per 100,000 of population of various southern cities from typhoid fever—Average for a period of five years.

[From United States census reports.]

Alexandria, Va	67.26	Paducah, Ky	82.08
Atlanta, Ga	69.54	Petersburg, Va	92.62
Charleston, S. C	84.38	Raleigh, N. C	75.28
Jacksonville, Fla	74.15	Richmond, Va	71.16
Kansas City, Mo	48.50	San Antonio, Tex	57.38
Key West, Fla	47.92	Savannah, Ga	49.30
Lynchburg, Va	99.22	Washington, D. C	63.20
Memphis, Tenn	45.22	For 1906	49.30
Mobile, Ala	68.34	Wheeling, W. Va	87.40
New Orleans, La	44.90	Wilmington, N. C	82.52
Norfolk, Va	54.52		

In view of the foregoing, it is evident that at the present time it is not possible to present conclusive proof as to the part played by the Potomac River water in the spread of typhoid fever in the District of Columbia. Therefore, the board reserves final decision on this subject until investigations, now in progress at the Hygienic Laboratory, have been completed.

Although views may differ concerning the relative part played by water, milk, contacts, and other factors in the spread of typhoid fever, there is a general agreement that the successful control of the disease lies in destroying the infection as it leaves the body; that is, we must try to prevent the infection of our food and drink and our environment.

Finally, it must be borne in mind that the typhoid problem in Washington does not differ radically from that of many other communities. It is part of a world-wide problem. The disease is endemic throughout the length and breadth of our large country and prevails to a greater or less extent in almost every civilized community. There is a constant interchange of infection through social and commercial intercourse. The situation in Washington has therefore been considered, not only with regard to local conditions, but also in relation to studies that have been made upon the disease in other cities and in other countries.

I.—EPIDEMIOLOGY.

EPIDEMIOLOGY.

In the study of the prevalence of typhoid fever in the District of Columbia we investigated all cases reported to the health office during the period from June 1 to November 1, 1906, a total of 868 cases. It was not practicable for us to study the cases in clinical detail and generally the diagnosis as made by the attending physician was accepted; however, the histories of two cases pointed so strongly against their being typhoid fever that they were eliminated, leaving 866 cases for consideration in this report.

At the beginning of our studies of typhoid fever the correct diagnosis of cases was appreciated to be of first importance. With this in view the following circular letter was addressed to all the physicians in the District of Columbia.

PUBLIC HEALTH AND MARINE-HOSPITAL SERVICE,
HYGIENIC LABORATORY,
Washington, July 14, 1906.

MY DEAR DOCTOR: In view of the prevalence of typhoid fever in the District of Columbia, the United States Public Health and Marine-Hospital Service, with the cooperation of the health department of the District of Columbia, has undertaken an investigation of the origin and prevalence of this disease. The undersigned board of officers of the Service has been appointed by the Surgeon-General, with the approval of the Secretary of the Treasury, to conduct this investigation.

It is our desire to make the investigation as thorough and comprehensive in its scope as the means at our disposal and circumstances will permit, and we hope to secure your active aid and cooperation.

We shall be glad to make Widal tests, blood cultures, and Diazo tests in any cases that you desire. We are also authorized to make, for registered physicians, bacteriological and chemical examinations of water, milk, and other possible sources of typhoid infection.

All of these tests and examinations will be made free of cost at the Hygienic Laboratory, Twenty-fifth and E streets NW.

Very respectfully,

M. J. ROSENAU,
Director Hygienic Laboratory.
J. H. KASTLE,
Chief, Division of Chemistry.
L. L. LUMSDEN,
Passed Assistant Surgeon.

This letter met with a cordial response and had the twofold effect of bringing us in closer touch with the situation and of aiding in the diagnosis of doubtful cases.

In our study of cases the following blank form was used, and all the facts called for by this form minutely investigated for each case.

United States Public Health and Marine-Hospital Service—Hygienic Laboratory.

TYPHOID FEVER—CASE CARD.

Name, ———. Date of investigation, ———. Case No. ——.
Age, ——. Male or female, ———. White or colored, ———. Married or single, ———. Probable date onset of disease, ———. Date definite symptoms, ———.
Name and address of physician, ———.

RESIDENCE.

Residence when taken sick, —————; from ——— to ———.
Previous residences, —————; from ——— to ———.
Subsequent residence, —————; from ——— to ———.
Residence when infection was contracted, ———. Number of occupants, ——.
Servants, ——.
White—
Resident, ——.
Nonresident, ——.
Colored—
Resident, ——.
Nonresident, ——.
Connected with city water system? ——.
Connected with city sewerage system? ——.
Privy? ——. Location, ———.
Privy vs. well, ———.
Water-closets in house? ——. Water-closets in yard? ——.
Screens? ——. Flies? ——. Mosquitoes? ——. Ants? ——. Roaches? ——. Bedbugs, ——. Rats? ——. Mice? ——. Other vermin? ——.
General sanitary condition, ———.

OCCUPATION.

——— ———.
Place, ———; from ——— to ———.
Drinking water, ———. Sewage, ———. Other cases, ———. Flies, etc., ———.

WATER.

Kind used thirty days prior to onset of illness:
Boiled, ——. Filtered, ——. Bottled, ——; kind, ———. Soda water, ——; where, ———.
Ice:
Source, ———. In or for drinking, ———.

FOOD.

Where taken thirty days prior, ———.
Milk, thirty days prior, ———; from ———. Boiled, ——. Pasteurized, ——.
Ice cream, ———.
Milk used since illness; from ———. Bottles, ——.
Uncooked fruits and vegetables, thirty days prior, ———; from ———.
Oysters, ——. Clams, ——. Crabs, ——. Lobsters, ——. Other shellfish, ——. Fresh-water fish (Potomac), ——.

CONTACTS.

Cases in house (six months prior), ——. Cases in house near by (six months prior), ——. Association with infection, ——.

MISCELLANEOUS.

Domestic animals on premises: Dogs, ——. Cats, ——. Cows, ——. Horses, ——. Guinea pigs, ——. Birds, ——. Other animals, ——.
Disposal of feces and urine, ———.
Other means to prevent spread of infection:

SUMMARY.

Remarks: ———.

——— ———.

(Signature of investigator.)

All residences within the District of Columbia from which cases were reported were visited and inspected. The data relative to food, drink, etc., for the thirty days prior to the onset of illness were obtained by carefully questioning the patients themselves when their condition permitted it, also their relatives, and other persons acquainted with the patients' habits. In many instances it was necessary to make several visits to a home in order to gather all of the data desired for a given case. Statistics based upon statements obtained in this manner are subject to a certain amount of error; yet by exercising care and patience it was endeavored to reduce this error to a minimum. The great interest taken by the people of the District of Columbia in the typhoid-fever situation made the conditions favorable for obtaining full and correct information. Of the large number of persons interviewed in regard to cases, there were only two or three who did not show an apparent desire to aid us all they could in the investigation, and in only one instance was a sanitary inspection of the premises refused.

Of the 866 cases studied, the following data relative to sex, race, age, etc., were obtained:

SEX.

Four hundred and sixty-six cases occurred in males and 400 cases in females. According to the police census taken during the spring of 1906 the population of the District of Columbia consists of 157,303 males and 169,132 females, a total of 326,435 persons. Thus, while the males compose 48.18 per cent and the females 51.81 per cent of the population, 53.81 per cent of the cases reported were among males and 46.18 per cent were among females, showing a somewhat higher typhoid-fever morbidity among the males than among the females. Two conditions, no doubt, contribute to the higher rate among the males; first, due to habits of occupation, etc., men are more exposed to infection, and, secondly, during the summer months, when the disease is most prevalent in Washington, a relatively larger number of women than men leave the city.

RACE.

Five hundred and eighty-eight cases were among whites and 278 among negroes. According to the police census for the spring of 1906 there were in the District of Columbia 95,018 negroes. Thus negroes compose 29.10 per cent of the population, while the cases of typhoid fever among them composed 32.10 per cent of the total number studied.

The higher rate for the period among the negroes possibly may be accounted for by the larger proportion of the colored population remaining in the city during the summer months. As is shown by the reports of the health officer of the District of Columbia when longer periods of time, such as a calendar year, are considered, the typhoid fever morbidity rate of the whites is usually higher than that of the colored. The law requiring cases of typhoid fever in the District of Columbia to be reported was not enacted until February, 1902. During the period from February 26 to December 31, 1902, there were reported 5.12 white cases for each 1,000 of white population and 5 colored cases for each 1,000 of colored population. During the calendar year 1903 the rate was 3.78 per 1,000 for the white and 3.08 per 1,000 for the colored race; during 1904, 3.29 for the white and 2.88 for the colored; during 1905, 3.5 for the white and 3.13 for the colored.

While the incidence of the disease during each year of which we have statistics is less on the colored population than on the white, the death rate, as shown in Table No. 1, page 58, is higher among the colored. The lower morbidity rate reported among members of the colored race may be due to a relatively smaller number of cases among them being recognized and reported as typhoid, while the higher mortality rate may be due to the less favorable conditions under which cases in the colored race are generally treated. However, it is possible that members of the colored race, due to tissue peculiarities, are, when equally exposed, less susceptible to the infection than are whites, but when the disease is contracted they offer less resistance to its progress and consequently succumb more readily.

When we consider the large number of negroes in Washington living in crowded and generally insanitary courts and alleys, we would expect that if contact and flies play a very great part in the transmission of typhoid fever in the District of Columbia there would be more cases relatively among the negro population than among the white population of the city. The contrary, however, seems to be the case.

AGE.

The following table gives the ages of the cases arranged according to sex. The youngest case was 8½ months and the oldest 68 years. By decades 140 of the cases were under 10 years, 278 between 10 and 20 years, 259 between 20 and 30 years, 118 between 30 and 40 years, 47 between 40 and 50 years, and 24 over 50 years.

Age, sex, and number of cases.

Years.	Male.	Female.	Total.
0– 4 inclusive	19	13	32
5– 9 inclusive	53	55	108
10–14 inclusive	75	56	131
15–19 inclusive	82	65	147
20–24 inclusive	79	64	143
25–29 inclusive	57	59	116
30–34 inclusive	41	34	75
35–39 inclusive	21	22	43
40–44 inclusive	13	11	24
45–49 inclusive	15	8	23
50–54 inclusive	5	5	10
55–59 inclusive	5	5	10
60–64 inclusive	0	0	0
65–69 inclusive	1	3	4
Total	466	400	866

IMPORTED CASES.

In determining whether the infection in a given case was contracted in or out of the District of Columbia, the whereabouts of the person during the thirty days prior to the onset of the first symptoms were considered and the incubation period of the disease recognized as being about from eight to twenty-five days. In many instances where persons spent a part of this time out of the District it was not possible to determine positively whether the infection was contracted in or out of the District, and therefore the cases were considered under the following heads:

	Cases.
(*a*) Infection undoubtedly contracted out of the District of Columbia	80
(*b*) Infection probably contracted out of the District of Columbia	32
(*c*) Infection contracted in or out of the District of Columbia (chances about equal)	34
(*d*) Infection probably contracted in the District of Columbia	32
(*e*) Infection undoubtedly contracted in the District of Columbia	681
(*f*) No information regarding whereabouts obtainable	7
Total	866

As the number who actually contracted the infection out of the District can not be determined with absolute accuracy, the fairest

estimate seems to be one based on the percentage of chances of contracting the infection out of the District for the number of cases under each of the above heads as follows:

		Cases.
(*a*)	80 cases, chances 100 per cent	80
(*b*)	32 cases, chances 75 per cent	24
(*c*)	34 cases, chances 50 per cent	17
(*d*)	32 cases, chances 25 per cent	8
(*e*)	681 cases, chances 0 per cent	0
(*f*)	7 cases, chances (?) per cent	(?)
	866 Total	129

On this estimate, and eliminating the seven cases about which no information regarding whereabouts during thirty days prior to onset of illness was obtained, 15.01 per cent of the cases investigated contracted the infection out of the District of Columbia.

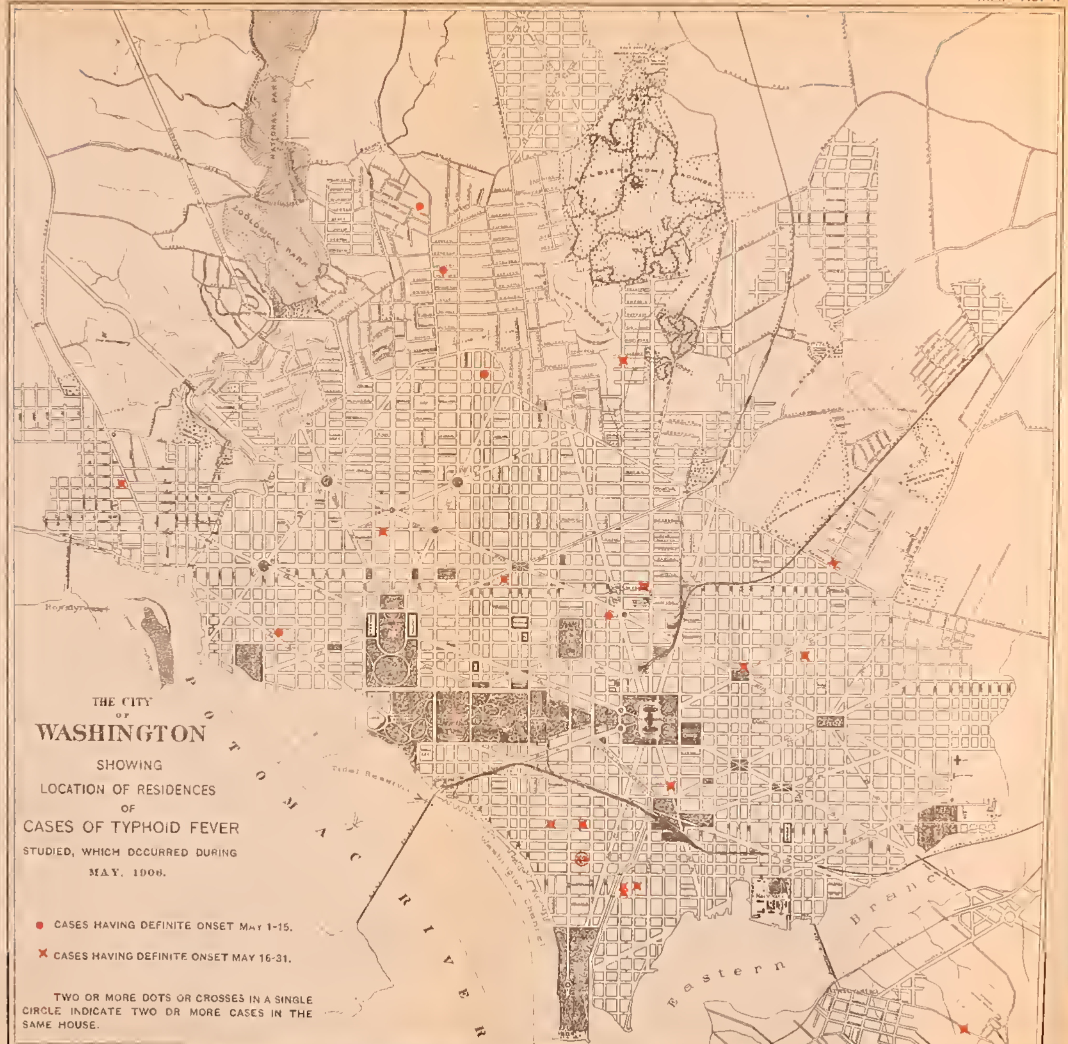
No attempt was made to make a detailed epidemiological investigation of the cases which contracted the infection out of the District. Therefore most of the following data apply to the 747 cases comprised under (*c*), (*d*), and (*e*) of the above classifications.

PREVALENCE.

In Table II, page 58, is shown the cases according to date of definite onset. As the cases studied were those reported from June 1 to October 31, inclusive, this table does not include all of the cases that actually occurred in May and in the latter half of October, as some of these were reported prior to June 1 or subsequent to October 31. But all of the cases having a definite onset during the period extending from June 1 to about October 15 are embraced in the table. The actual time at which the infection was contracted could probably be more accurately calculated if the date of the occurrence of the first slight symptoms could be ascertained definitely for each patient, but after the interval of two or three weeks, which usually had elapsed between the onset of the disease and the investigation of the case, the memory of the patients, their relatives, or friends often was not clear as to the date on which the patient began to have feelings of lassitude, slight headache, or other mild symptoms, while the date on which the patient was taken with definite symptoms, such as a rigor, severe headache, etc., or on which he had to take to bed usually would be remembered with fair distinctness. In the investigation we endeavored to obtain both the date of occurrence of the very first symptoms and the date of definite symptoms, but as the statements regarding the former were in so many instances vague and unsatisfactory, the date of the onset of definite symptoms has been used in the tables, charts, etc., in this report. By going back about three weeks from the date of onset of definite symptoms as given, the date on which

No. 1.

HINGTON, D. C.



THE NORRIS PETERS CO., WASHINGTON, D.C.

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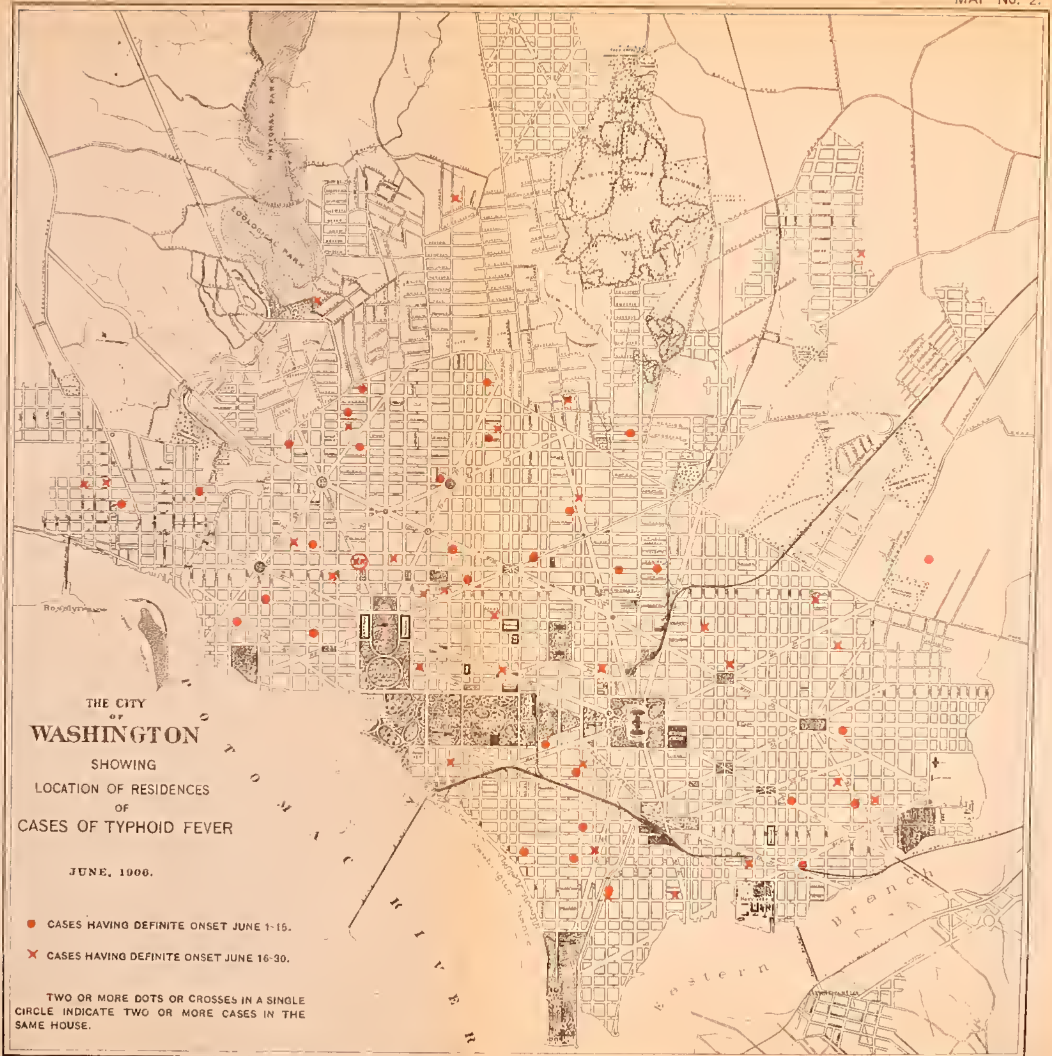

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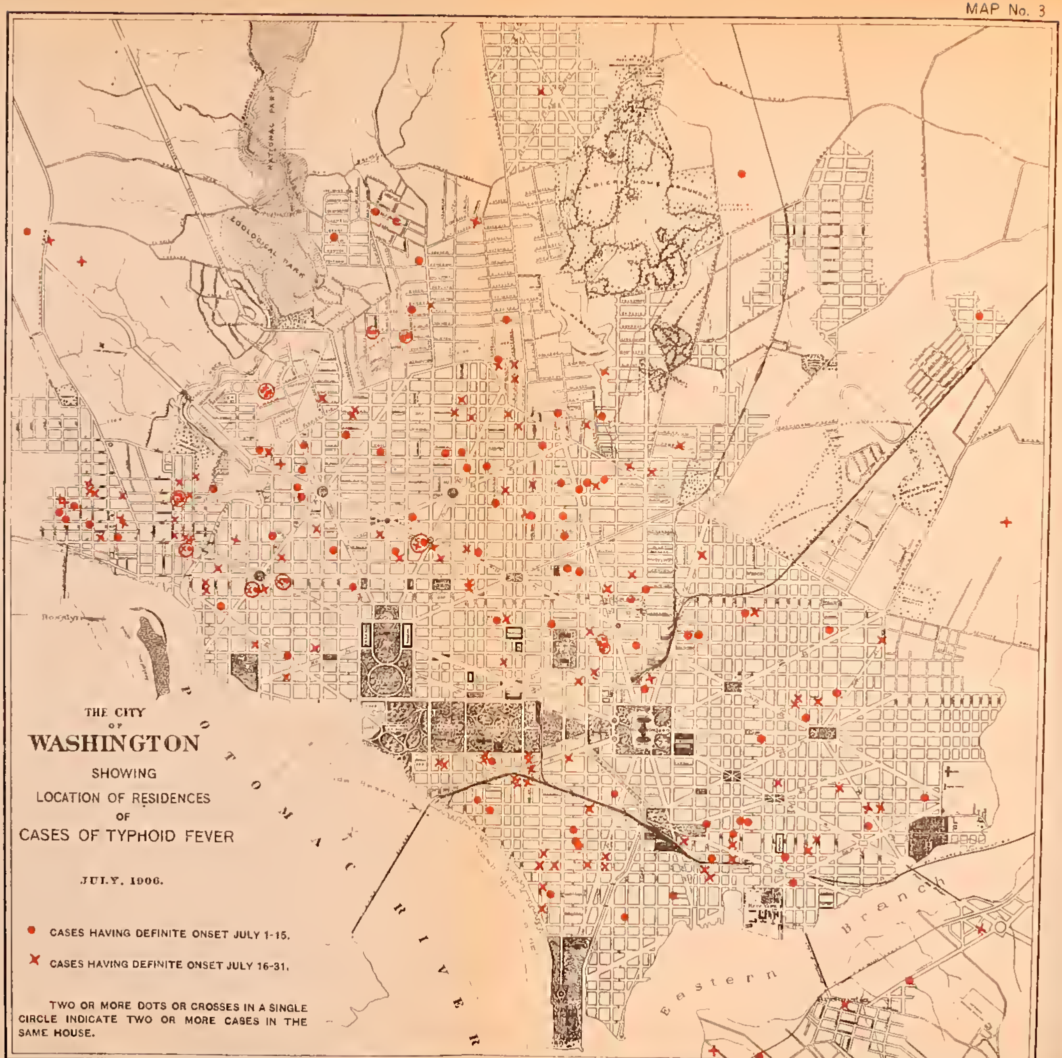
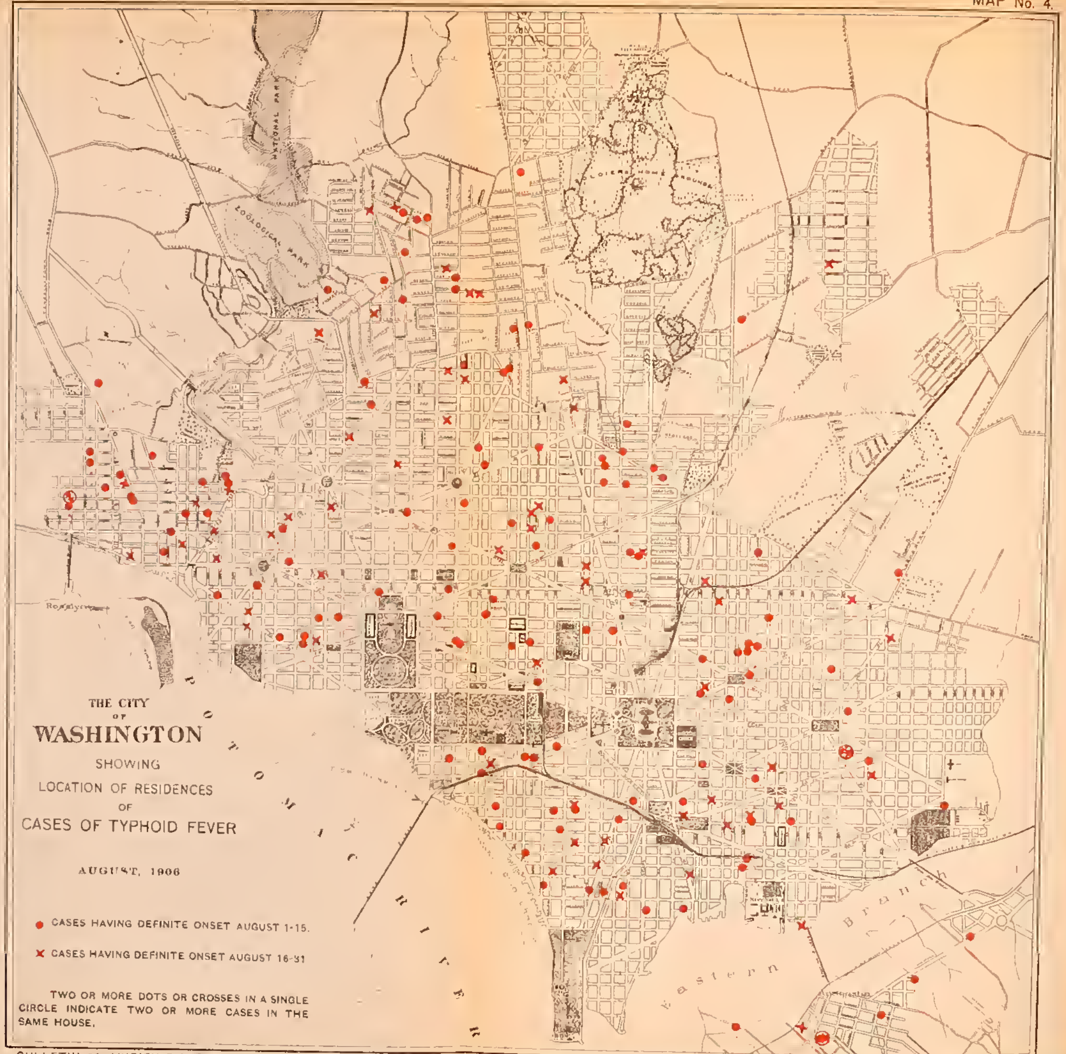

THE CITY
OF
WASHINGTON
SHOWING
LOCATION OF RESIDENCES
OF
CASES OF TYPHOID FEVER
JULY, 1906.
CASES HAVING DEFINITE ONSET JULY 1-15.
CASES HAVING DEFINITE ONSET JULY 16-31.
TWO OR MORE DOTS OR CROSSES IN A SINGLE CIRCLE INDICATE TWO OR MORE CASES IN THE SAME HOUSE.
POTOMAC RIVER
Eastern Branch
NATIONAL PARK
ZOOLOGICAL PARK
Rosslyn

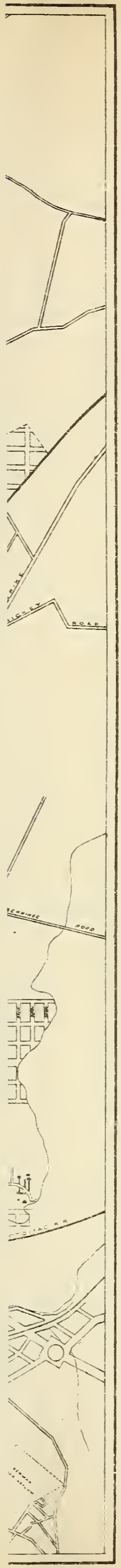
No. 1.

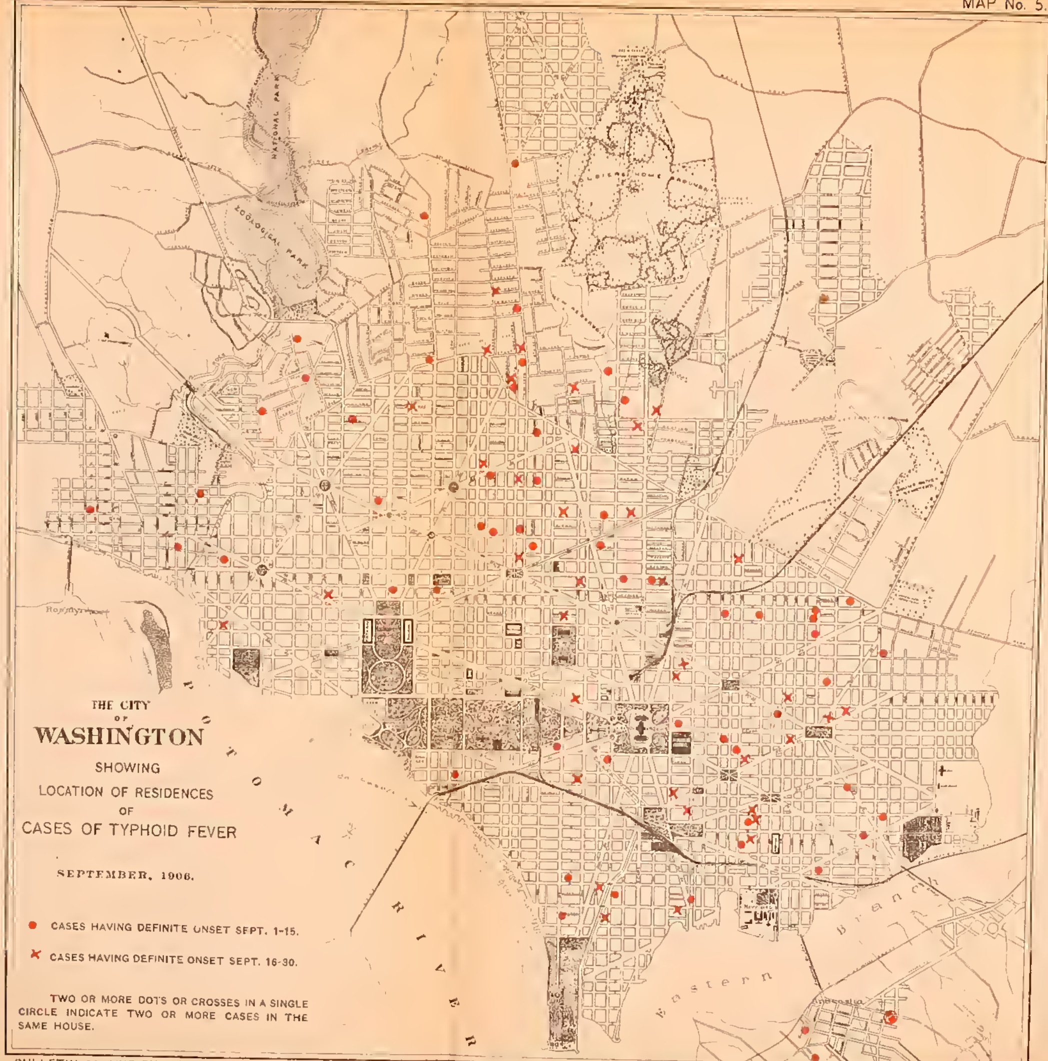
NGTON. D. C



THE NORRIS PETERS CO. WASHINGTON, D.C.

P No. 5.





BULLETIN 35, HYGIENIC LABORATORY, P. H. & M. H. S.

THE NORRIS PETERS CO., WASHINGTON, D. C.

P No. 6.

the infection was contracted probably will be approached with a fair degree of accuracy.

The following table shows the progress of the disease based upon the date of onset:

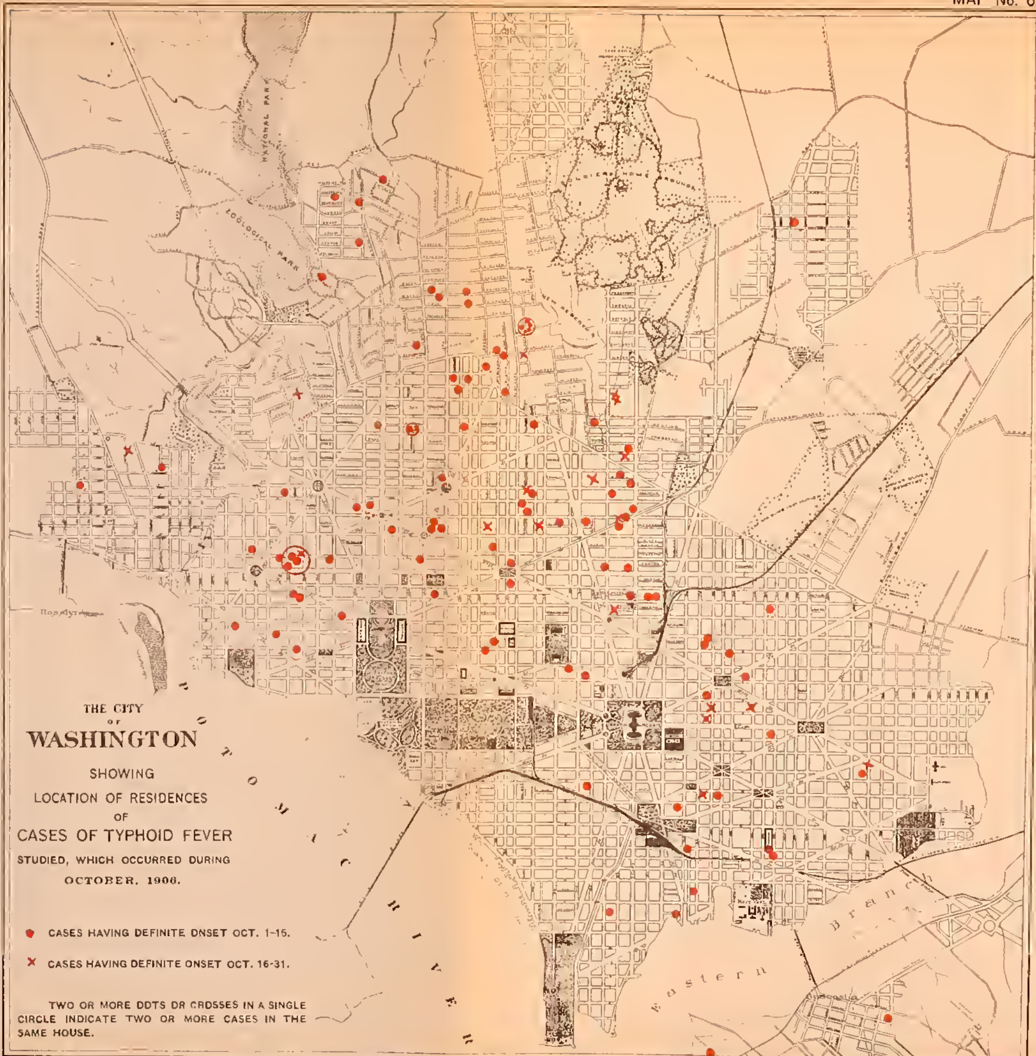
	Cases.
May 1 to 15 (incomplete)	6
May 16 to 31 (incomplete)	16
June 1 to 15 (complete)	32
June 16 to 30 (complete)	32
July 1 to 15 (complete)	101
July 16 to 31 (complete)	131
August 1 to 15 (complete)	139
August 16 to 31 (complete)	70
September 1 to 15 (complete)	59
September 16 to 30 (complete)	41
October 1 to 15 (complete)	98
October 16 to 31 (incomplete)	22
Total	747

In considering the occurrence of cases by these periods, the striking features are the sudden rise in the early part of July, the continued high rate to about the middle of August, and the marked fall in the rate between the middle and last of August (see charts Nos. 1 and 2). This decrease in the rate continued through September. In the early part of October the rise was due largely to the milk outbreak among the customers of milk dealer No. 4. (See Chart No. 3.)

If the first symptoms of the disease appear about two weeks after the infection is contracted and are followed by symptoms of definite onset about a week later, then the causes which operated to effect the rate must have become greatest about June 10 and continued until about July 25, when they suddenly and markedly decreased. This decrease in the causes, which occurred in the latter part of July and continued through August, is one of the most remarkable facts brought out in the course of our studies, and it is difficult to explain why a decrease in the causes should have taken place at this season, which seemed most favorable to many of the factors which spread the infection of typhoid fever, such as flies, contacts, etc.

The possibility of a prolonged period of incubation in some cases must be borne in mind. It has occurred to us that perhaps a certain number of persons contract the infection earlier in the year and carry the bacilli in their intestinal tract, but do not show symptoms of the disease until subjected to the depressing influences of the hot weather, which usually occurs in Washington early in July.

Maps Nos. 1, 2, 3, 4, 5, 6, and 7 show the distribution of cases according to place of residence when the disease was contracted. The general distribution of the cases throughout the District of Columbia during each of the periods is striking.



THE NORRIS PETERS CO. WASHINGTON D.C.

The occurrence of deaths from typhoid fever in the District of Columbia, as reported to the health officer from May 1 to December 31, 1906, was as follows:

May—		September—	
1 to 15	3	1 to 15	15
16 to 31	7	16 to 30	6
June—		October—	
1 to 15	4	1 to 15	10
16 to 30	5	16 to 31	17
July—		November—	
1 to 15	9	1 to 15	10
16 to 31	12	16 to 30	8
August—		December—	
1 to 15	10	1 to 15	1
16 to 31	22	16 to 31	3

A comparison of this table with the one above, showing the progress of the disease based on the date of onset, shows that the typhoid fever death rate does not indicate in detail the progress of the causes of the disease chronologically and emphasizes the importance in the study of a typhoid fever situation of determining the rate of occurrence of cases by date of onset of illness.

SANITARY CONDITION OF RESIDENCES.

The general sanitary condition of the residences at which patients had lived when the infection probably was contracted were considered under four heads: "Good," "Fairly good," "Rather bad," and "Bad." Under "Good" are included residences at which all the conditions such as structure of house, state of cleanliness, ventilation, plumbing, etc., were good; under "Fairly good" residences at which most of the conditions were good, but with one or more somewhat faulty—for example, a residence with everything in good condition except for a somewhat damp and rather poorly ventilated cellar or basement would be classed as "Fairly good;" under "Rather bad" were included those with one condition faulty or several somewhat faulty; while under "Bad" were included those with one or more very faulty or with all the conditions somewhat faulty.

The sanitary conditions of the residences were as follows:

Good	253
Fairly good	243
Rather bad	158
Bad	92
Not determined	1
Total	747

These figures show that the disease certainly did not prevail to any unusual extent among persons living under poor sanitary conditions. On the contrary, it seemed to be more prevalent among persons living in residences of the better class.

Cellar or basement at residence.

No cellar or basement	359
Cellar in good condition	46
Cellar damp, but otherwise good	43
Cellar damp and poorly ventilated	58
Basement in good condition	124
Basement damp, but otherwise good	64
Basement damp and poorly ventilated	20
Cellar or basement not noted	33
Total	747

DISPOSAL OF SEWAGE.

Of the 747 cases 671 lived at residences connected with the city sewerage system and at which there were water-closets, 72 lived at residences not connected with the city sewerage system and at which there were privies, 2 at residences not connected with the city sewerage system and at which there were neither water-closets nor privies, and 1 at a residence not connected with the city sewerage system, but having water-closets which discharged into a cesspool. One was at a residence where the method of disposing of sewage was not noted.

Of the cases living at residences connected with the city sewerage system 240 were at residences having water-closets in the house only, 257 at residences having water-closets in the yard only, and 174 at residences having water-closets in both house and yard. Thirty-two of the cases occurred at residences where seepage from the privies into the well or spring appeared to be possible.

SCREENS.

Two hundred and sixty cases occurred among persons living in houses that were well screened, 390 in houses that were not screened, 94 in houses that were screened in part, and 3 in houses where the screening was not noted.

INSECTS AND VERMIN.

FLIES.

Eleven cases occurred among persons living in houses where there were practically no flies, 287 in houses where there were few, 367 in houses where there were flies in moderate number, 40 in houses where there were many, 39 in houses where they were swarming, and 3 in houses where the number was not noted.

MOSQUITOES.

Twenty-six cases occurred among persons living in houses where there were no mosquitoes, 263 in houses where there were few, 381 in houses where there were mosquitoes in moderate number, 65 in houses where there were many, and 12 in houses where the number was not noted.

ANTS.

Three hundred and nine cases occurred among persons living in houses where there were no ants, 155 in houses where there were few, 249 in houses where there was a moderate number, 20 in houses where there were many, and 14 in houses where the number was not noted.

ROACHES.

Two hundred and two cases occurred among persons living in houses where there were no roaches, 151 in houses where there were few, 332 in houses where there was a moderate number, 29 in houses where there were many, and 33 in houses where the number was not determined.

BEDBUGS.

Two hundred and sixty-one cases occurred among persons living in houses where there were no bedbugs, 100 in houses where there were few, 324 in houses where there was a moderate number, 13 in houses where there were many, and 49 in houses where the number was not determined.

RATS ON PREMISES.

Three hundred and seventy-five cases occurred among persons living in houses where there were no rats, 49 at houses where there were few, 301 at houses where they were in moderate numbers, 11 at homes where there were many, and 11 at homes where the number was not determined.

MICE.

Three hundred and thirty-seven cases occurred among persons living in houses where there were none, 121 in houses where there were few, 270 in houses where they were in moderate numbers, 5 in houses where there were many, and 14 in houses where the number was not determined.

In obtaining these data in regard to insects, rats, and mice, etc., as much as possible was learned by inspection, and for the remainder the statements of persons living at the residence were accepted. Most of the cases investigated occurred in a period when the average temperature was high and the rainfall great—conditions probably favorable to most insect life and also tending to cause large numbers to remain in houses.

DOMESTIC ANIMALS ON PREMISES.

One hundred and ninety-seven cases occurred among persons living at houses where there were dogs, 266 cases at houses where there were cats, 8 at houses where there were guinea pigs, 7 at houses where there were rabbits, 1 at houses where there were pet mice, 36 at houses where there were horses, 7 at houses where there were cows, 5 at houses where there were hogs, 2 at houses where there were goats, 133 at houses where there were chickens, 3 at houses where there were ducks, 1 at houses where there were turkeys, 32 at houses where there were canary birds, 1 at houses where there were mocking birds, and 1 at houses where there were parrots.

To discuss what part, if any, in the spread of the infection was played by domestic animals would be mere speculation. In some instances, where cats were seen lounging in water-closets on the seats soiled with feces, and into which closets the stools of typhoid fever patients were being emptied from time to time without previous disinfection, the possibility of cats conveying the infection was recognized. In three cases histories were given that the patients, within two or three weeks before they became ill, were taking care of pet cats which had sickened and died of some disease the nature of which had not been recognized.

In one case the patient, during the thirty days just prior to onset of illness, handled pigeons which had died of an epidemic disease.

FRUITS AND VEGETABLES.

In only 401 cases could positive statements regarding the eating of uncooked vegetables be obtained. Of these, 302 were stated to have eaten uncooked vegetables, such as tomatoes, lettuce, or celery, and 99 not to have done so.

On account of the complex condition of the provision business in the District of Columbia it was not possible to trace the fruits and vegetables used by the cases investigated to any particular farm or place.

The free exposure to flies of fruits and vegetables in the stalls of the large markets of Washington was noted. The possibility of foodstuffs, not only fruits and vegetables but also meats, becoming infected by flies, etc., must be kept in mind.

SHELLFISH AND FRESH-WATER FISH.

The following table shows the number of patients who ate shellfish or fresh-water fish from time to time within the thirty days prior to the onset of illness:

	Yes.	No.	Not stated.
Oysters	60	655	32
Clams	64	647	36
Lobsters	8	708	31
Crabs	190	516	41
Fresh-water fish	205	504	38

For 42 cases positive statements were given that no shellfish nor fresh-water fish of any kind were eaten.

These data indicate that shellfish could not have been the means of transmitting the infection to any considerable number of cases.

The small number of patients who gave a history of having eaten oysters is accounted for by the fact that the cases studied occurred between May 1 and October 31, during which period comparatively few oysters are eaten in the District of Columbia.

WATER.

Of the 747 cases 721, or 96.54 per cent, gave a definite history of having used unboiled Potomac water supplied through the regular city system as the sole, principal, or occasional source of water for drinking during the thirty days prior to onset of illness.

Of the 26 remaining cases 7 drank no unboiled Potomac water, and of these 7 all but 2 drank unboiled water from wells, etc., outside of the District of Columbia; of the 2 who drank boiled Potomac water solely 1 had been nursing a case of typhoid fever during the three weeks prior to the onset of illness and the infection was attributed to contact. Seven cases used no city water, boiled or unboiled, for drinking. Of these 4 used water from private wells solely for drinking, one water from a public city pump solely, which case was attributed to milk infection, 1 bottled water solely, and 1 melted ice solely, which case was attributed to infected milk. For 12 cases positive information regarding the use of unboiled city water for drinking could not be obtained. Of these 5 occurred in an institution for children, where boiled water was provided for the use of the inmates, but free access was had to the unboiled tap water; these 5 cases were attributed to milk infection.

Considering as a group the 26 cases which occurred among persons of whom definite histories of having drunk unboiled Potomac water could not be obtained, 2 were attributed to infection by contact, 7 to infection by milk, 1 to infection by ice cream, and 5 spent part of the

thirty days prior to onset of illness outside of the District of Columbia and may have contracted their infection while away. Seventeen used unboiled milk supplied by the dealers of the District of Columbia.

The following table gives the source of water used for drinking purposes during the thirty days preceding onset of illness by the 747 cases studied:

Water used by cases thirty days prior to illness.

Raw tap water:[a]	
Solely	443
Principally	196
Occasionally	73
Occasionally (?)	12
Boiled tap water:	
Solely	2
Principally	47
Occasionally	15
Filtered tap water:	
Solely	1
Principally	10
Occasionally	3
Occasionally (?)	1
Public pumps:	
Solely	1
Principally	3
Occasionally	94
Occasionally (?)	31
Bottled water:	
Solely	1
Principally	7
Occasionally	13
Private wells or springs in the District of Columbia:	
Solely	4
Principally	36
Occasionally	33
Various sources out of the District of Columbia:	
Principally	0
Occasionally	69
Melted ice:	
Solely	1
Principally	1

These figures point to the water as a factor in the spread of the infection, but we must remember that perhaps an equally large proportion of the general population drink the raw tap water. For a full discussion of the relation of the Potomac River water to typhoid fever see page 30, *et seq.*

[a] By raw tap water is meant that the water was not boiled or filtered after it left the tap.

SODA WATER.

Of the 747 cases, 310 drank soda water. In 45 cases definite information regarding the use of soda water was not obtainable, and 392 gave a definite history of not having drunk soda water within thirty days prior to onset of illness.

The water used in making the soda water sold at practically all the public fountains in Washington is the unboiled tap water.

OCCUPATION.

In the following table is given the occupation of the cases, along with the number of persons in the District of Columbia, according to the census of 1900, engaged in such occupations. As the cases occurred in 1906 and the census was taken in 1900, the figures are not strictly comparable.

Occupations.	Number of persons engaged in occupations (census of 1900).			Number of cases of typhoid fever.		
	Male.	Female.	Total.	Male.	Female.	Total.
Agricultural pursuits.						
Agricultural laborers	614	....	614	1	....	1
Dairymen	117	....	117	3	....	3
Farmers, planters, and overseers	217	....	217	1	....	1
Gardeners, nurserymen, florists, etc	462	....	462	1	....	1
Professional pursuits.						
Architects, designers, draftsmen	478	....	478	3	....	3
Dentists	234	....	234	1	....	1
Electricians	461	....	461	1	....	1
Engineers (civil, etc), surveyors	351	....	351	1	....	1
Lawyers	1,445	....	1,445	2	....	2
Literary and scientific persons	239	....	239	3	....	3
Officials (Government)	900	....	900	1	....	1
Teachers, professors, etc	390	1,598	1,988	1	7	8
Domestic and personal service.						
Barbers, hairdressers	860	....	860	2	....	2
Bartenders	581	....	581	4	....	4
Housekeepers, stewardesses	....	529	529	....	4	4
Janitors, sextons	511	....	511	1	....	1
Laborers, not specified	12,476	263	12,739	32	1	33
Launderers, laundresses	474	7,192	7,666	2	6	8
Nurses and midwives	231	1,311	1,542	1	4	5
Restaurant and saloon keepers	612	112	724	2	....	2
Servants and waiters	2,898	15,231	20,129	6	37	43
Watchmen, policemen, firemen, etc	1,667	....	1,667	4	....	4
Trade and transportation.						
Agents	1,511	....	1,511	2	....	2
Bankers and brokers	323	....	323	1	....	1
Bookkeepers and accountants	837	482	1,319	5	2	7
Clerks and copyists	11,523	4,697	16,220	24	7	31
Draymen, hackmen, teamsters, etc	3,994	....	3,994	24	....	24
Hostlers	410	....	410	1	....	1
Hucksters and peddlers	526	....	526	2	....	2

Occupations.	Number of persons engaged in occupations (census of 1900).			Number of cases of typhoid fever.		
	Male.	Female.	Total.	Male.	Female.	Total.
Trade and transportation—Continued						
Merchants and dealers:						
Retail	3,945	418	4,363	6	....	6
Wholesale	176	....	176	1	....	1
Messengers, errand, and office boys	1,345	....	1,345	8	....	8
Newsboys, newspaper carriers	104	....	104	4	....	4
Officials of banks and companies	390	....	390	2	....	2
Porters and helpers in stores, etc	921	....	921	4	....	4
Salesmen and saleswomen	2,644	1,320	3,964	9	8	17
Steam railroad employees	1,185	....	1,185	9	....	9
Stenographers and typewriters	521	708	1,229	2	7	9
Street railway employees	817	....	817	5	....	5
Telegraph and telephone operators	307	(?)	307	1	....	1
Mechanical and manufacturing.						
Bakers	622	....	622	1	....	1
Blacksmiths	775	....	775	2	....	2
Bookbinders	405	279	684	....	1	1
Brick and tile makers	195	....	195	1	....	1
Butchers	569	....	569	2	....	2
Carpenters and joiners	2,298	....	2,298	10	....	10
Confectioners	212	....	212	2	....	2
Dressmakers	....	2,993	2,993	....	1	1
Engineers, firemen (not locomotive)	1,116	....	1,116	2	....	2
Engravers	144	....	144	2	....	2
Iron and steel workers	300	....	300	3	....	3
Machinists	1,392	....	1,392	12	....	12
Marble and stone cutters	272	....	272	1	....	1
Masons (brick and stone)	1,153	....	1.153	1	....	1
Painters, glaziers, varnishers, etc	1,441	....	1,441	2	....	2
Paper hangers	363	....	363	1	....	1
Plasterers	465	....	465	4	....	4
Plumbers, gas and steam fitters	1,074	....	1,074	4	....	4
Printers, lithographers, pressmen, and presswomen	2,842	481	3,323	9	3	12
Miscellaneous.						
Persons attending school	18,788	21,116	39,904	101	98	199
Infants and small children	....	....	....	36	32	68
Housewives	....	[a]35,000	35,000	....	78	78
Decorators	....	....	....	....	1	1
Postmen	....	....	....	1	....	1
Packers of seeds, Saratoga chips, etc	....	....	....	....	2	2
Piano tuners	....	....	....	2	....	2
Inmates of institutions	....	....	....	6	2	8
No occupation	....	....	....	9	44	53
Not stated	....	....	....	2	3	5
Total	....	....	....	399	348	747

[a] Our estimate.

INFECTION BY CONTACT.

Forty-six of the cases gave a history of having had free and intimate association with typhoid patients in the febrile stage of the disease. Of these, 11 were attributed to infection by milk, and 3

were in contact with cases outside of the District of Columbia, leaving 32 cases, or 4.28 per cent of the 866 cases, which were attributed to infection by direct contact. Among these 32 cases were 2 instances of colored servants contracting the disease from white employers, but no instances were determined in which white persons contracted the disease from colored servants.

Fourteen cases gave a history of slight or occasional association with patients in the febrile stage. Of these, 5 were attributed to infection by milk, leaving 9 for consideration as suspected contact cases. In 21 cases indirect conveyance of the infection by persons or flies was strongly suggested. Twelve cases had free and intimate association with patients just convalescing from typhoid fever. One case developed the disease within thirty days after moving into a house which had been vacated by persons among whom there had been typhoid fever during the three months prior.

It seems fair to estimate the chances of these 44 cases having become infected by contact at about 50 per cent; and so adding 22 of these to the 32 which were considered almost certainly infected by contact, there are 54 cases, or 6.23 per cent of the total, which may reasonably be attributed to infection by contact.

No satisfactory information could be obtained upon the question of direct or indirect contact with persons recently (three to four months) convalescent from the disease or with chronic bacillus-carriers. Therefore, it may be argued that more cases may have contracted their infection in this way; how many more is problematical.

That the bulk of the infection in Washington is not spread by contact is indicated by the fact that the number of cases diminished through the latter half of August and through September, while all the conditions for the spread of the disease by this means seemed favorable; and, further, by the fact that the disease prevails to a much greater extent in Washington than in some other American cities in which the conditions for the spread of the disease by contact appear to be equally favorable. On the other hand, arguments may be adduced indicating that contacts play a larger rôle in the problem, but on account of our meager data we prefer to leave the subject for further study, which is now going on in the Hygienic Laboratory.

The difficulty of determining just how many cases should be attributed to infection by contact will, we believe, become evident to anyone studying the epidemiology of typhoid fever in a large city. To estimate in figures the actual number infected by contact among the cases which occurred in the District of Columbia during the period in which we were studying the situation would be mere speculation, and in attributing a given number of cases to infection by contact, milk, or any other one factor, we have taken into consideration all

of the factors learned of which may have applied to the given case and then attributed the infection to the factor which seemed most probably applicable.

In 45 houses more than one case occurred within a period of three months, and in these 45 houses there were, all told, 103 cases. Of these, 35 were attributed to milk infection, 28 to infection by contact, direct and indirect, and 40 to factors undetermined. The largest number which occurred in one house was 6; all of these 6 cases were attributed to milk. In fact, the occurrence of several cases, especially among children, within a few days in the same house was often found to be a good indication of a milk outbreak, and it was through such an occurrence in an institution, toward the latter part of our studies, that our attention was first attracted to the outbreak among the customers of milk dealer No. 4.

Among the many kindly suggestions given us by those interested in the typhoid fever situation in the District of Columbia was one (from Mr. Whipple) that possibly many of the cases among white persons in Washington were contracted from colored servants. This point was considered in connection with the 306 cases last studied. Of these cases, 237 were at homes at which there were no servants. Three were at homes where white servants were employed and resided; 22 were at homes where colored servants were employed and resided; 1 was at a home where a white servant was employed, but who went to his own home at night; 43 were at homes where colored servants were employed, but who went to their own homes at night. Two of the cases were in the persons of colored servants who resided at the homes where they were employed. In no instances were histories obtained of cases of typhoid fever existing among the persons in the homes of colored servants during the 3 or 4 weeks prior to the onset of the cases in the families of their white employers. The reluctance with which servants usually gave information regarding illness in their homes led us to believe that their statements should be accepted with considerable reservation.

PROPHYLAXIS.

Of the 866 cases, 374, or 43.18 per cent, were treated at hospitals. The time of admission to hospitals of cases which were considered as having contracted the infection in the District of Columbia was as follows:

	Cases.
Within 5 days after onset of illness	190
Within 10 days after onset of illness	69
Within 15 days after onset of illness	18
Within 20 days after onset of illness	4
Within 25 days after onset of illness	4

	Cases.
Within 30 days after onset of illness	1
Within 90 days (relapse) after onset of illness	1
Not determined	6

Of the 80 cases considered as having undoubtedly contracted the infection out of the District of Columbia, 53 were treated at hospital, and of the 32 which were considered as almost certainly having contracted the infection out of the District, but possibly as having contracted the infection in the District, 28 were treated at hospital. Of these 81 imported cases treated at hospital 66 were taken from places out of the District of Columbia direct to hospital for treatment, and 15 were taken to hospital after being treated at private residences in the District of Columbia as follows:

At private residence for—	Cases.
2 days	3
3 days	3
4 days	2
5 days	1
6 days	1
7 days	1
10 days	2
12 days	1
15 days	1
Total	15

The good percentage of cases treated at hospital was one of the most encouraging features met with in the course of our studies, because at hospitals the facilities to prevent spread of infection are generally much better than at private residences. The hospital treatment of cases suggests itself as one of the best measures to prevent the spread of the disease and should be encouraged, especially among those who are unable to carry out the proper precautions at home.

Of the 492 cases treated at private residences, 119 were attended by professional nurses. The treatment of stools and urine with disinfectants was efficient for 145 cases, inefficient for 286, of doubtful efficiency for 51, and method of treatment not ascertained for 10. Of the 286 patients whose stools and urine were inefficiently treated the lack of efficiency was due to the small quantity of disinfectant used for 197 and to shortness of time of exposure of excreta to disinfectant for 89. For 51 patients the treatment of stools and urine was considered of doubtful efficiency, because the material used for effecting the disinfection was some patented preparation, the value of which as a disinfectant is doubtful.

In 89 cases no attempt whatever at disinfection of excreta was made. It would seem that attending physicians should be held responsible for the proper treatment of stools and urine of patients

suffering with typhoid fever. In a good many instances we were informed by the members of the families of the patients that they had received no instruction from their physicians regarding care of the patients' dejecta, and we learned of some instances in which attending physicians had had the patients' attendants stop the intelligent use of carbolic acid or chlorinated lime and use instead some patented preparation, somewhat more aesthetic, perhaps, but certainly of very much less efficiency than one of the standard and cheaper germicides.

Of other measures to prevent spread of infection—such as treatment of clothing, bedding, dishes, etc., used by patients, and care of the hands of persons attending patients—the precautions carried out for 212 of the cases were fairly efficient, for 270 inefficient, and for 10 not stated.

To sum up the epidemiological findings:

	Cases.	Percentage.
Infection contracted out of the District of Columbia	129	14.89
Infection attributed to milk or ice cream	85	9.81
Infection attributed to contact	54	6.23
Accounted for	268	30.93
Unaccounted for	598	69.07
Total	866	100.00

Or considering only the 747 cases, of which 681 undoubtedly and 66 probably, contracted the infection in the District of Columbia, we have—

	Cases.	Percentage.
Attributed to infection by milk or ice cream	85	11.3
Attributed to infection by contact	54	7.3
Accounted for	139	18.6
Unaccounted for	608	81.4
Total	747	100.00

TABLE NO. I.—*Typhoid fever death rate per 100,000 of population, according to race, for the last twelve years.*

Year.	Total.	White.	Colored.
1895	73.8	64.3	94.1
1896	51.1	46.8	60.4
1897	43.6	37.5	56.6
1898	64.3	50.2	95.3
1899	67.2	47.3	111.0
1900	74.1	64.0	96.7
1901	56.4	42.8	87.1
1902	74.0	71.5	79.7
1903	45.0	38.1	60.8
1904	43.8	35.5	63.4
1905	43.9	40.0	53.3
1906	49.3	35.4	83.1
Average	57.2	47.78	78.45

TABLE NO. II.—*Typhoid cases, May to October, 1906, by date of onset.*

Date.	May.	June.	July.	August.	September.	October.
1	1	4	5	23	13	6
2	0	0	6	13	9	5
3	1	5	8	7	2	6
4	0	1	8	8	3	3
5	0	3	6	7	2	5
6	0	2	4	7	7	5
7	1	2	7	12	2	6
8	0	1	8	11	1	12
9	0	1	3	8	4	5
10	0	5	9	15	3	7
11	0	1	2	4	4	7
12	0	1	4	6	3	13
13	0	1	3	6	2	3
14	3	3	8	3	2	6
15	0	1	20	9	2	9
16	1	1	5	3	3	3
17	0	2	7	6	1	6
18	1	0	4	6	4	1
19	1	2	3	1	5	1
20	0	1	15	19	4	6
21	3	4	12	2	4	2
22	0	1	5	1	3	1
23	0	3	9	2	1	0
24	0	4	3	2	2	1
25	1	1	21	11	4	0
26	2	3	2	2	1	1
27	1	2	8	4	0	....
28	2	3	12	4	4	....
29	0	1	6	1	2	....
30	1	4	10	3	3	....
31	3	....	7	3	....	....
Total	22	64	232	209	100	120

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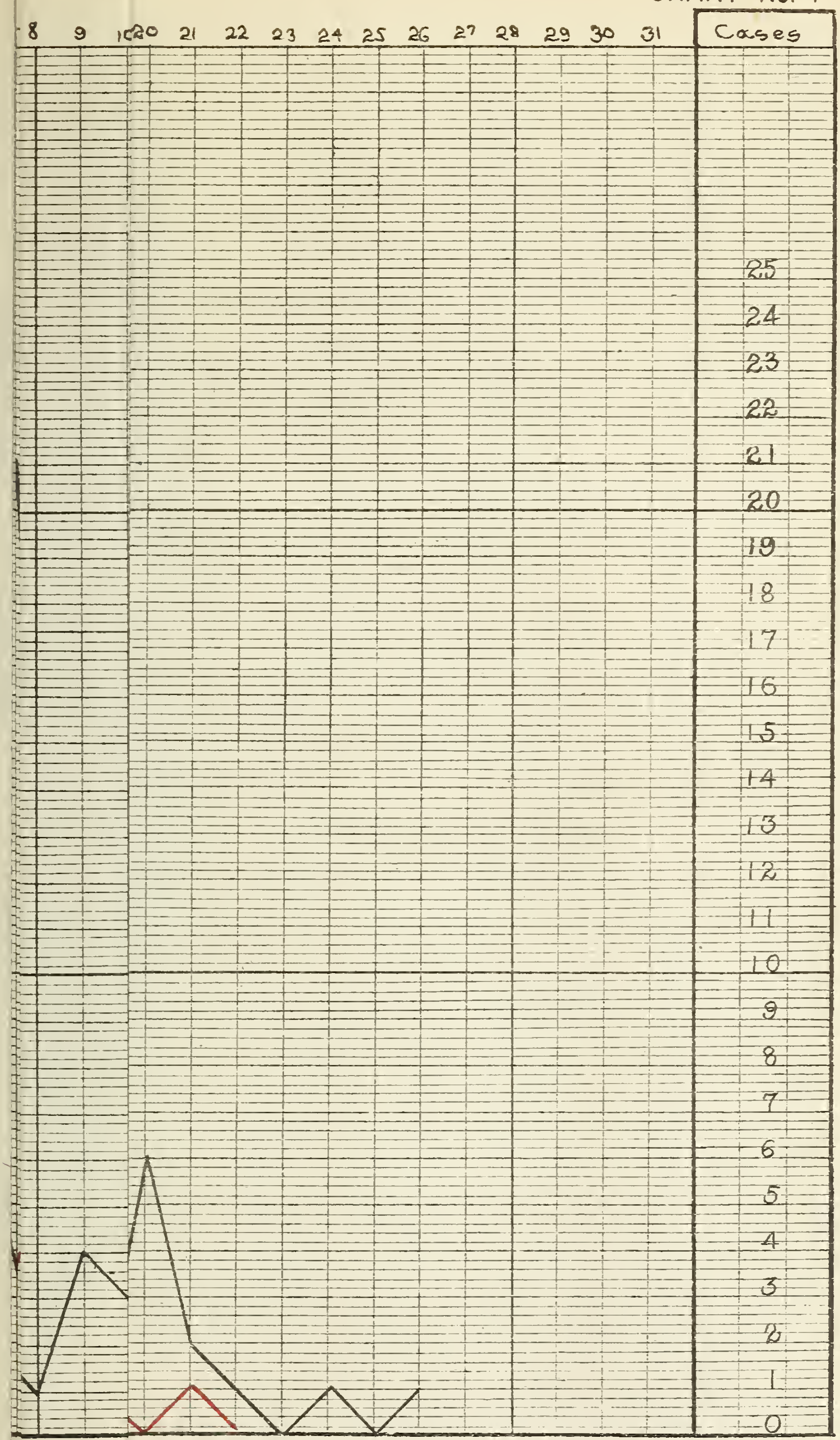
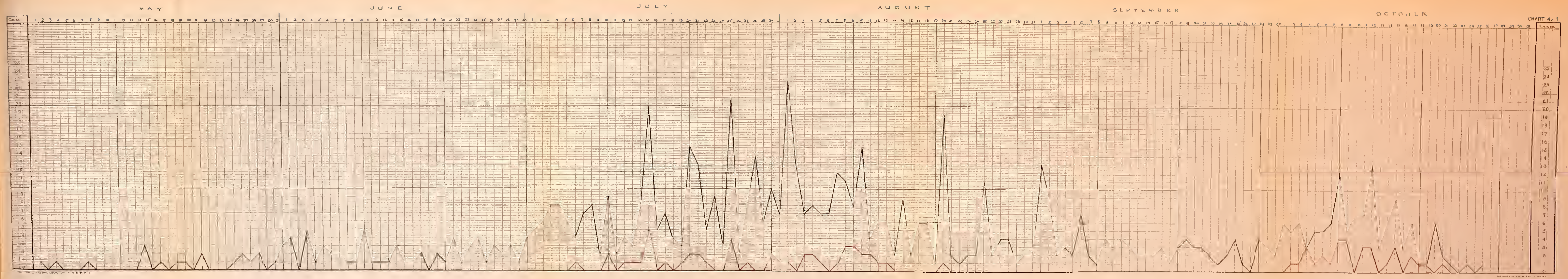
CHART No. 1



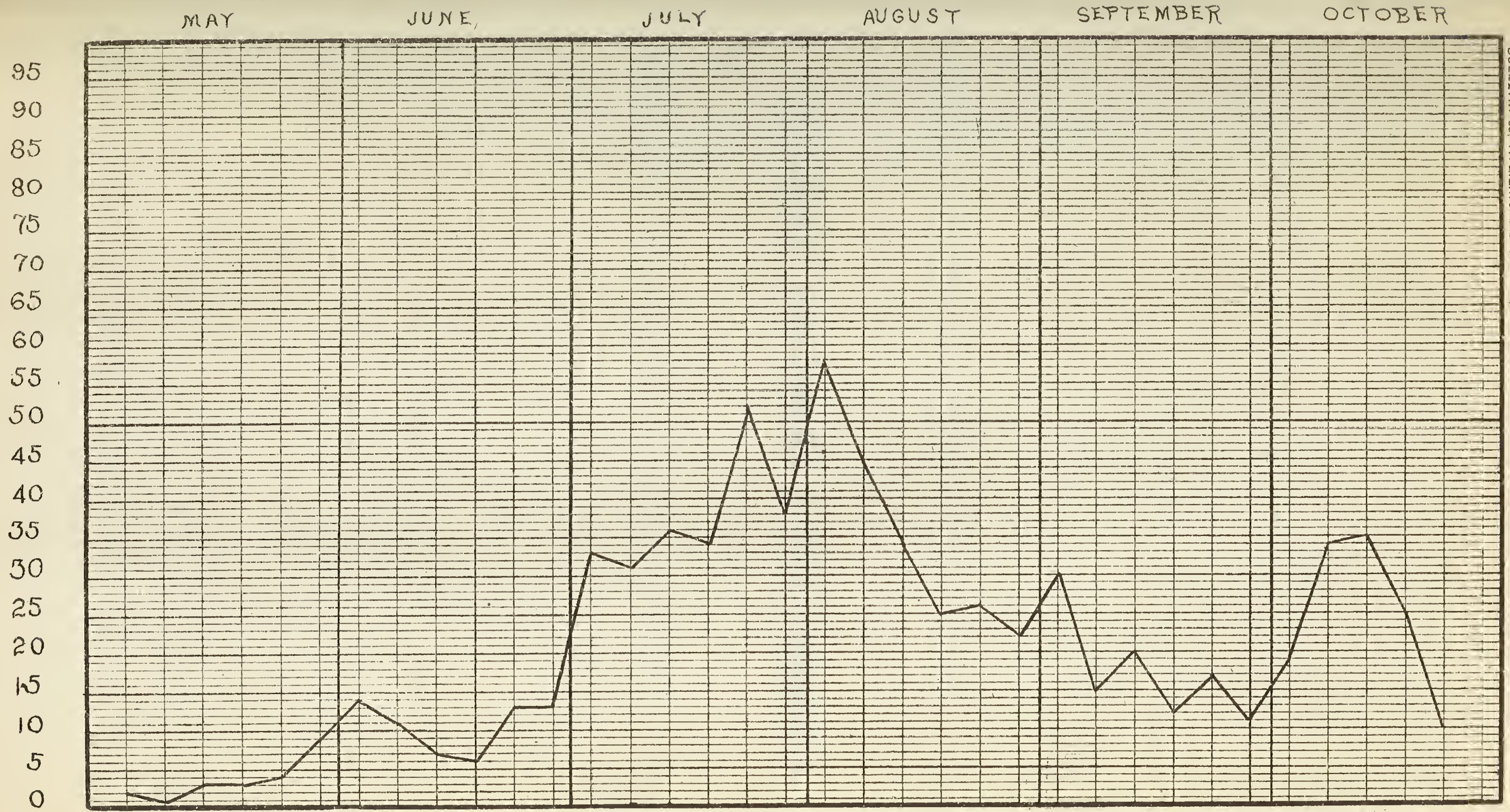
THE NORRIS PETERS CO., WASHINGTON, D. C.



——— = CASES OF TYPHOID FEVER IN THE DISTRICT OF COLUMBIA, CHARTED ACCORDING TO DATE OF ONSET OF DISEASE.

——— = CASES DUE TO MILK INFECTION

CHART No. 2



TYPHOID CASES CHARTED ACCORDING TO DATE OF ONSET OF ILLNESS, IN FIVE-DAY PERIODS, MAY TO OCTOBER, 1906.

THE NORRIS PETERS CO., WASHINGTON, D. C.

II.—MILK AND OTHER DAIRY PRODUCTS.

MILK AND OTHER DAIRY PRODUCTS.

Milk was responsible for about 10 per cent of the cases of typhoid fever occurring in the District of Columbia between June 1 and November 1, 1906.

Three distinct milk outbreaks were studied, traceable to contamination from typhoid fever cases at the dairies or dairy farms. The record of milk infection for previous years is as follows:

1905. Of the 1,097 cases	23
1904. Of the 1,006 cases	None.
1903. Of the 1,055 cases	19
1902. Of the 1,474 cases [a]	7

It may therefore be safely assumed that infected milk is a frequently recurring cause of the disease in the District of Columbia.

In our epidemiological studies we found that the 747 cases which contracted their infection in the District of Columbia gave the following history in regard to the use of milk within thirty days prior to illness:

As a beverage	488
On fruits and cereals, but not as a beverage	90
In hot tea or coffee only	50
As ice cream only	65
None	40
Not stated	14
Total	747

Of the 105 cases in which it was stated that no milk was used, 65 gave a history of having eaten ice cream, while 40 gave a history of not having used milk or cream in any form within thirty days prior to the onset of the disease.

In chart No. 3 is shown the number of cases which occurred among the customers of the various milk dealers in the District of Columbia. This diagram demonstrates graphically the three milk outbreaks among the customers of dealers Nos. 4, 13, and 85, as follows:

	Cases.
Dealer No. 4. October 2 to 21	32
Dealer No. 13. July 6 to August 20	35
Dealer No. 85. July 30 to August 13	12
Due to milk	79
Due to ice cream	6
Total	85

[a] From the records of the health office, District of Columbia.

It is probable that contaminated milk was also responsible for scattering cases, although of this we are unable to present conclusive proof. A study of chart No. 3, leaving out the condensation of dots along the lines of milk dealers Nos. 4, 13, and 85, which represent the three milk outbreaks, shows the remaining dots roughly scattered along the routes of the milk dealers more or less uniformly.

The ratio of the number of cases of typhoid fever occurring among the customers of each milk dealer to the number of persons using that milk is instructive. This ratio is determined from the number of cases per 100,000 gallons of milk sold by each dealer.

The number of gallons of milk sold by each dealer was obtained only for the months of July, August, September, and October, and the ratio is based upon the number of cases of typhoid fever and the number of gallons of milk sold during the same period.

MILK AND TYPHOID FEVER.

The importance of clean and good milk from a public-health standpoint is well recognized by sanitarians, but the danger that lurks in contaminated milk does not seem to be generally understood. This ignorance seems glaring among the dairymen and others who handle the milk supplies for the District of Columbia.

Dr. George M. Kober, in his admirable monograph, "Milk in Relation to Public Health,"[a] has collected 195 epidemics of typhoid fever occurring in various parts of the world, due wholly to milk. In this same paper will also be found a compilation of 95 epidemics of scarlet fever and 35 epidemics of diphtheria due to milk.

Doctor Kober says:

> It is a remarkable fact that every attempt to improve the purity of this invaluable article of food, especially for infants, children, and invalids, the sick and convalescent, should be promptly opposed by the milk industry, which constitutes a strong spoke in the commercial wheel, and evidently considers it meddlesome interference with their trade.
>
> These men evidently do not know and can not know, that such hydra-headed diseases as cholera infantum, scarlet fever, and diphtheria have been disseminated in the milk supply; that typhoid-fever epidemics have been thus caused, and that milk may be the vehicle of the germs of tuberculosis and other infectious diseases and morbific agents.
>
> Pure natural milk can only be secured at dairies with sanitary buildings, a pure water supply, healthy, well-fed and well-cared-for cows, a well-equipped and well-kept milk room, provisions for thorough cleanliness, intelligent people in charge, and clean methods throughout. There are a number of persons, thanks to the training received at the dairy schools, who make an honest effort to place on the market milk obtained under such conditions, but by far the majority are indifferent to hygienic requirements, and therefore matters of this kind should not be left to the individual, but the principles which ought to be carried out should be embodied in effective laws and accepted and enforced in a practical sense.

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[a] Senate Doc. No. 441, 57th Cong., 1st sess., Washington, 1902.

Honorable men will not object to regulations calculated to promote the purity of their product and the health of their customers, and as many of the most serious faults are the result of ignorance rather than intentional neglect, the difficulties will be materially lessened by proper education and trade competition.

Our own studies closely confirm Doctor Kober's observations and give further evidence of the danger from contaminated milk.

The typhoid bacillus may reach the milk in any one of many ways. Usually it is by direct or indirect contact with cases of the disease. Often convalescents or persons in the first stages of typhoid fever milk the cows or handle the milk. Sometimes the same hands that nurse the sick, milk the cows. Sometimes the infection is carried to the milk indirectly through water or by means of the cleansing rags and other fabrics that have become contaminated with the dejecta. Most of the 195 outbreaks described by Doctor Kober were traced to cases of typhoid fever on the dairy farms. When one remembers how readily the typhoid-fever infection is communicated from person to person by direct or indirect contact, it is easy to understand how readily the infection may be conveyed from the sick to the milk.

The question of "bacillus-carriers" is a live problem when applied to milk. When we remember that many people harbor the typhoid bacillus without being sick, in fact without ever having had the disease, and that persons may discharge great numbers of the bacilli for months and in some instances for years after apparent recovery, it is easy to understand how the milk may become infected, and yet a searching inquiry fail to find the source of the danger. This emphasizes the fact that the fewer persons who come in contact with milk the better, and those who have actually to handle the milk should exercise scrupulous cleanliness and be under strict medical supervision.

The use of pure water for cleaning cans and bottles can not be too strongly emphasized. It can be readily understood how a few typhoid bacilli, finding their way from water into a bottle, can, or vat of warm milk, may in this very favorable culture medium multiply very rapidly and so contaminate the milk to a dangerous degree.

Neufeld [a] considers that, next to water, milk plays by far the most important rôle in the epidemiology of typhoid fever.

Schüder [b] collected statistics of typhoid epidemics, 110 of which were due to milk, against 462 due to water.

The English literature in particular contains many references to milk as a vehicle of spreading the disease.

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[a] Neufeld, F.: Typhus. Handbuch der pathogenen Mikroorganismen, by W. Kolle and A. Wassermann, vol. 2, p. 204.

[b] Schüder. Zeitschr. f. hyg., Bd. 38, 1901, p. 343.

Hart,[a] Rossi,[b] and Schlegtendal[c] have collected many outbreaks attributed to this source.

A recent outbreak of typhoid fever in Kolozsvar was not only traced by Konradi[d] to milk, but the typhoid bacillus was actually isolated from 2 of the 33 samples of milk examined. It appears that one of the dairymen had a mild case of typhoid fever, which did not prevent him from doing the milking and thus infecting the milk directly.

Magrath's[e] recent investigations in Massachusetts have again shown that our skepticism regarding the purity of milk is not misplaced. The disease has been prevalent in Massachusetts this summer, and the State board of health, with its usual efficiency, has investigated the situation promptly and thoroughly.

In most of the outbreaks investigated it was found that milk was the agent through which the infection was conveyed. The epidemics in Wellesley and Needham were traced to a single farm, and the disease has ceased to spread since this fact became known and proper precautions were taken.

The typhoid bacillus grows and multiplies in milk with great rapidity, especially if the milk is not kept cool. In fact, milk is one of the best culture media for the typhoid bacillus. Unfortunately, the milk may teem with myriads of these organisms without in the least changing the appearance, the odor, or the taste of the milk. We therefore have no ready means of knowing whether a particular glass of milk may or may not be contaminated with the typhoid bacillus.

Milk epidemics often break out with the same explosive violence as water epidemics. They are characterized by the fact that they usually affect the children and women especially.

Buttermilk and cream, and possibly other dairy products, also may act as vehicles of infection. Several of the 85 cases attributed by us to milk probably received their infection in buttermilk or cream.

Ice cream in particular must engage the attention of the sanitarian, for it is known to be a vehicle by which the infection is spread. It is admitted, in the District of Columbia at least, that the worst milk is often used for the purpose of making ice cream. Further, the making and handling of this delusive delicacy is often under the poorest possible sanitary conditions.

The use of ice cream during the thirty days prior to onset of illness

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[a] Hart. Brit. med. journ., June–Aug., 1895.

[b] Rossi. La clinica moderna, 1897.

[c] Schlegtendal. Deut. Vierteljahrschr. f. öff. Ges.-Pflege, Bd. 32, p. 287.

[d] Konradi, D. Centblt. f. bakt., I Abt., vol. 40. 1905, p. 31.

[e] Magrath, ——. Boston med. and surg. journ., editorial, vol. 155, 1906, p. 522.

by the 747 cases studied was as follows: Four hundred and seventy-six ate it from time to time, 222 ate none, and for 49 no definite statements regarding its use were obtainable. Six of the cases studied by us were traced to infected ice cream. Five of these 6 cases ate ice cream made from the milk sold by dairyman No. 4 and 1 case ate ice cream made from milk sold by dairyman No. 13 during the periods when the products of these dairies gave evidences of being infected.

INSPECTION OF THE CITY DAIRIES.

Of the numerous dairies in the District, the following 38 were inspected:

Belmont Dairy Company, E. P. Thomas, president, 2016 Fourteenth street NW.
Linden Dairy, G. M. Timmins, president, 2021 Fourteenth street NW.
Standard Dairy and Ice Company, 1333 Fourteenth street NW.
National and Aspen Grove Dairy, J. W. Gregg, 614 O street NW.
Sharon Dairy, C. Thompson, proprietor, 324 B street SW.
Klondike Dairy, H. L. Meeks, 611 L street NW.
Evergreen Dairy, F. R. Horner, Ninth and O streets NW.
Alderney Dairy, G. W. Wiley, 1718 Eighth street NW.
Union Valley Dairy, J. W. Estes, 300 I street NW.
St. Clair Dairy, ——— Heflin, 1245 M street NE.
Farmers' Dairy, W. W. Johnson, 1406 Tenth street NW.
Bellevue Dairy Farm, Chris. Heurich, proprietor; H. W. Blunt, manager, 1431 P street NW.
Hamilton Dairy, W. R. Selecman, 1450 P street NW.
Walker-Gordon Laboratories, W. Davidson, superintendent, 1020 Connecticut avenue NW.
Griffiths' Swiss Dairy, H. Griffiths, 403 East Capitol street.
Anandale Dairy, J. W. Castle, 146 C street NE.
Our Farm Dairy, W. W. Hartranft, 107 Seventh street NE.
Walker Hill Dairy, W. A. Simpson, 530 Seventh street SE.
Jersey Dairy, J. J. Bowles, 460 K street NW.
Ingleside Dairy, W. B. Dodge, 1757 Pennsylvania avenue NW.
Dulin's Dairy, F. M. Johnson & Bro., 1021 Twentieth street NW.
Chevy Chase Dairy, Geo. A. Wise & Bro., 3310 P street NW.
Hickory Hill Dairy, Walters & Watson, 2306 L street NW.
Lewinsville Farm Dairy, Storm & Sherwood, 1708 Wisconsin avenue NW.
Springdale Dairy, H. H. Trundle, 720 Twentieth street NW.
Mt. Rocky Dairy, H. L. Alden, 211 Tenth street SW.
Thompson's Dairy, Theresa, Ellen and Grace Thompson, 511 Four-and-a-half street SW.
Fairfax Dairy, A. B. Walters, 2012 H street NW.
Pearl Dairy, A. Mowett, 1828 Fourteenth street NW.
Mountain View Dairy, S. E. Powell, Fifth and Florida avenue NW.
Hartung's Dairy, John Hartung, 108 Florida avenue NW.
Green Meadow Dairy, J. T. Barber, 330 New Jersey avenue NW.
Glenmore Dairy, R. L. Simpson, 1211 C street SW.
Spa Spring Dairy, H. A. Mills, 55 Rhode Island avenue NW.
Mt. Pleasant Dairy, Ford E. Young, 1405 Park Road NW.

Colorado Heights Farm Dairy, Mrs. Rebecca Pyles, Grant Road, Tennallytown, D. C.
Chestnut Farm Dairy, George M. Oyster, jr., 1116 Connecticut avenue NW.
Shenandoah Dairy, P. N. Disher, 636 H street NE.

Numerous stores where milk is retailed in small quantities were also inspected and will be commented upon later.

The information derived from the inspection is summarized as follows:

SOURCE OF THE MILK.

Only 3 of the 38 dairies inspected claim to sell milk exclusively from their own farms. The other 35 purchase milk from numerous farms scattered largely throughout the neighboring counties of Maryland and Virginia. Some of the larger dairies obtain their milk supply from as many as 40 farms. It is stated that when a dairy has a sudden demand for an extra supply or receives a short shipment, it does not hesitate to purchase from other sources. This further complicates the difficult problem of tracing milk infections.

In all there are about 1,000 dairy farms in the neighboring counties of Maryland and Virginia supplying milk to the District of Columbia. Some cream is obtained from more distant points in Pennsylvania and New York.

LENGTH OF TIME MILK IS USUALLY KEPT AT THE DAIRY.

In 17 of the 38 dairies inspected some of the milk is received between 8 and 10 o'clock in the morning and does not leave the dairy until the following morning. In most of the others the milk is received late in the afternoon or evening and leaves on the early morning delivery. In but a few instances is the milk distributed as soon as received. It is evident that there is a lack of cooperation between the dairy farms, the railroads, and the city dealers, as there is a loss of practically a day at many of the large dairies inspected.

METHOD OF SERVING MILK.

All the dairies supply milk in bottles. A few of them maintain an additional service by cans and dippers.

HOW THE BOTTLES ARE FILLED.

At 11 of the dairies inspected the bottles are filled by machines; at the remaining 27 they are filled by hand, using either a dipper or a 2-gallon can for this purpose. Some of the machines are sloppy and the overflow milk is sometimes caught and rebottled.

It is the general custom to allow the paper caps or stoppers to lie around without special precautions against contamination by dust and flies. They are always placed in the bottles by hand; and the hands are seldom as clean as should be.

METHOD OF CLEANING BOTTLES.

The bottles are washed either by hand or by machine. Only a few dairies have bottle-washing machines. As a rule, the bottles are first washed in warm water containing "wyandotte," soapine, soap, "savagran," "Swift's powder," or other similar preparations. They are then rinsed in cold tap water. Some of the dairies have poor facilities for obtaining hot water. Many have rotary brushes to assist in the first washing. These brushes are either turned by mechanical power or by foot treadle. In the latter case it was found that the operator of the washer sometimes neglects to keep the treadle in motion.

For the most part the washing of the bottles is exceedingly unsatisfactory, both from a sanitary standpoint and from one of mechanical cleanliness. The first water in which they are washed, containing an alkaline soapy substance, is usually warm but not hot enough to be uncomfortable to the hand; it is therefore scarcely sufficient to destroy infection that may return in the bottles. The bottles are then quickly passed into another tub of clear water, which soon becomes milky and alkaline, making a very good culture medium for the preservation and growth of certain infections that may be present, especially typhoid.

It is the usual practice to leave the bottles in the dairy right side up, exposed to the dust of the street and stable and to contamination by flies, mice, etc., before filling. A few dairymen turn the bottles upside down and protect them from this risk.

DISINFECTION OF THE BOTTLES.

In only 5 of the 38 dairies inspected can it be said that the bottles are disinfected. In these 5 instances the disinfection consists of steaming or scalding with boiling water. In at least two of these five the bottles were passed through a washing machine which provided for their disinfection by a jet of steaming water, but at the time of inspection the water used in the machine was not hot enough. The steaming or scalding of the bottles should, of course, be the last process to which they are subjected prior to cooling and filling.

When we remember that milk bottles are frequently used by householders for many purposes, that they often get into the sick room and run many chances of contamination with the infectious agents of typhoid fever or other diseases, it would not be unreasonable to require their disinfection by all dairymen.

CLEANING OF SHIPPERS' CANS.

As a general thing the milk cans are simply rinsed with tap water and returned to the shippers. In a few instances the flushing out with cold water is followed by hot water or steam. In one or two dairies the cans are scrubbed.

SCREENS AND FLIES.

Flies are a great nuisance in all but one or two of the dairies inspected, and very few dairymen use intelligent measures in ridding their dairies of this danger. Thirty-two of the 38 dairies inspected are not screened at all; 5 are partly screened, and only one was found to be thoroughly protected in this manner. The stable, in close proximity to the dairies, provide breeding places for flies and make this feature of the dairy business a particularly dangerous one from a sanitary standpoint.

Almost all the dairies have water-closets, sometimes in foul condition, either in the same building or in the rear of the dairy, or more commonly in the adjoining stable, so that there are many chances for flies, etc., to carry infection from these water-closets to the milk. Nearly all the dairies stable their horses to the rear of the bottling room.

EMPLOYEES.

Persons employed to handle milk show a woeful disregard of cleanliness as it is understood in a sanitary sense. The milk is contaminated largely through ignorance and through lack of cleanliness. In only a single instance in the 38 dairies inspected are employees required to change their clothes and wear clean white suits or to wash their hands before beginning work. In two instances we learned of employees living at homes in which cases of typhoid fever were being treated. There is practically no medical supervision to eliminate workmen who may contaminate the milk during the early stages of disease or during the three or four months following recovery, during which periods such persons frequently discharge large numbers of virulent typhoid bacilli.

At one dairy an employee was seen to put his finger alternately into the milk and then into his mouth, and back again into the next can of milk, in order to assure himself that the milk was sweet before adding it to the general supply.

In one instance the driver of a milk wagon was observed filling pint bottles out of quarts. He evidently ran out of pints, and hence used the empty bottles collected on his route for this purpose. After filling two pint bottles from one quart bottle he licked the mouths of the bottles "clean" with his tongue and then applied the usual paper cap.

In another instance a driver was seen to fill some empty bottles he had collected on his route by dipping the bottles, including his fingers, into the can of milk.

LOCATION AND GENERAL CONDITION.

Dairies are usually situated on the first floor; sometimes in dingy basements or cellars. Some of them are in poor sanitary condition, others fair; a few were in fine order at the time of inspection.

The location of most of the dairies is pernicious so far as general sanitary surroundings are concerned. Many of them are situated near squalid settlements or abut on unkempt alleys. Close relation between almost all dairies and stables has already been referred to.

There are a large number of small purveyors of milk in the District. Through a technicality in the law these small places, mostly small corner stores, while subjected to inspection, are immune to the general sanitary requirements of the health department. The conditions under which the milk is kept and retailed in some of these places can better be imagined than described. In some instances we found small grocery stores selling a cent's worth of milk from bottles or cans, while upstairs or in an adjoining room typhoid fever cases were being treated. The same hands that cared for the sick dispensed milk. Flies passed freely from the sick room to the store, and the chances of conveying the infection from the patient to milk and other articles sold in the store were favorable.

THE COWS.

Good milk can only come from healthy cows. But as cattle are not subject to typhoid fever, and this infection always enters the milk after leaving the animal, we made no special study of the condition of the cows furnishing the milk supply of the District of Columbia.

EXAMINATIONS OF THE MILK FURNISHED THE DISTRICT OF COLUMBIA.

During the warm months a number of samples of milk were purchased on the open market and examined in the Hygienic Laboratory. The samples of milk were examined bacteriologically, chemically, and physically, as far as such methods serve a useful purpose from the public health standpoint.

A total of 215 samples of milk, obtained from 44 dairies, were examined and the results, condensed in tabular form, are given on pages 73 to 79.

OBTAINING SAMPLES.

The samples of milk for the above determinations were purchased at the dairies, from milk wagons on the street, or delivered to the laboratory or to houses in various parts of the city. It is therefore evident that the samples studied fairly represent the average milk actually supplied to the bulk of the householders of Washington.

TEMPERATURE OF THE MILK.

The temperature of each bottle of milk was taken, under the usual bacteriological precautions, as soon as the sample was obtained. Only 16 of the 172 samples of milk obtained during the warm weather had a temperature as low as 10° C. (50° F.).

The sanitary code of the New York City Board of Health considers milk to be adulterated the temperature of which is higher than 50° F. and section 54 of the code states that—

any milk found to be adulterated which has been brought into the city of New York or is held or offered for sale in said city may be seized and destroyed by any inspector or other officer of this Department authorized to inspect same.

The regulations for the sale and care of milk promulgated by the Boston Board of Health June 6, 1905, article 6, section 1, provide that:

No person, by himself or by his servant or agent, or as the servant or agent of any other person, firm or corporation, shall, in the city of Boston, sell, exchange or deliver, or have in his custody or possession with intent to sell, exchange or deliver, any milk, skimmed milk, or cream which contains more than 500,000 bacteria per cubic centimeter, or which has a temperature higher than 50° Fahrenheit.

The rapidity with which bacteria multiply in milk at a temperature somewhat above 50° F. was well shown by Freudenreich. In his experiment the milk contained 153,000 organisms per cubic centimeter and was exposed to a temperature of 59° F. It contained after—

	Bacteria per cubic centimeter.
1 hour	539,750
2 hours	616,250
4 hours	680,000
7 hours	1,020,000
9 hours	2,040,000
24 hours	85,000,000

Park emphasizes the fact that few, even the well informed, appreciate how great a difference a few degrees of temperature will make in the rate of bacterial multiplication. Milk rapidly and sufficiently cooled keeps almost unaltered for thirty-six hours, while milk that is insufficiently cooled deteriorates rapidly.

The great bulk of the milk offered for sale in the District of Columbia during the summer would have been considered adulterated according

to the sanitary code of New York and would have been excluded from sale according to the health regulations of the city of Boston on account of the temperature alone.

DIRTY MILK.

In addition to being old and warm, much of the milk sold in Washington is dirty. Fifty-one of the 172 samples examined showed no visible deposit in the original container after several hours' standing. Fifteen of the samples contained a very small amount of dirt, 98 contained a small amount of dirt, 8 contained much dirt, and 1 contained (mouse ?) feces.

This foreign matter (dirt) when examined under the microscope was found to consist of fecal matter, hair, epithelial and other cells, straw, bacteria, and all manner of extraneous substances that have no place in clean milk.

We made no quantitative weighings of the amount of dirt found in our samples, but only took note of the foreign matter visible to the naked eye, which settled down after a few hours' standing. Any housewife may satisfy herself of the presence or absence of foreign matter by this simple test. Good, clean milk should show no such deposit.

Comment upon this part of our work seems unnecessary. It is true that hair, cow excrement, and other substances found in the milk do not of themselves breed disease, and may not be so dangerous as the invisible pathogenic germs; but the one is as undesirable as the other is dangerous. The fact that such extraneous substances gain entrance to the milk in such large quantities is a sad commentary upon the cleanliness used in milking and the after care of the milk, and is an index of how readily the more insidious and less evident infections of typhoid fever, diphtheria, scarlet fever, etc., may likewise contaminate the milk.

THE NUMBER OF BACTERIA IN MILK.

The samples of milk were brought to the laboratory on ice, and as soon as received were plated upon agar-agar in Petri dishes in the usual way. The plates were incubated at 37° C., and the number of colonies which developed were counted by Mr. William Lindgren after twenty-four hours, sometimes at the end of forty-eight hours, in order to obtain a maximum growth.

The number of bacteria in a cubic centimeter of milk is no index of its contamination with typhoid; it is only an indication of the age, temperature, and cleanliness of the milk.

A study of the table shows that only 29 of the 172 samples examined contained less than 500,000 bacteria per cubic centimeter. The great

bulk of the milk sold in the District of Columbia last summer would, therefore, have been condemned according to the health regulations of Boston.

Park finds that milk starting with 12,000 bacteria per cubic centimeter in warm weather and 5,000 in cold weather, if quickly cooled to 46° F., and kept at that temperature, will, at the end of thirty-six hours, contain on an average less than 50,000 bacteria per cubic centimeter; and if cooled to 40° F., will average less than its original number. Park states that:

> With only moderate cleanliness, such as can be employed by any farmer without adding appreciably to his expense, namely, clean pails, straining cloths, cans or bottles, and hands, a fairly clean place for milking, and a decent condition of the cow's udder and the adjacent belly, milk when first drawn will not average in hot weather over 30,000 and in cold weather not over 25,000 bacteria per cubic centimeter. Such milk, if cooled to and kept at 50° F., will not contain at the end of twenty-four hours over 100,000 bacteria per cubic centimeter. If kept at 40° F. the number of bacteria will not be over 100,000 per cubic centimeter after forty-eight hours.
>
> If, however, the hands, cattle, and barns are filthy, and the pails are not clean, the milk obtained under these conditions will, when taken from the pail, contain very large numbers of bacteria, even up to a million or more per cubic centimeter.
>
> Any intelligent farmer can use sufficient cleanliness and apply sufficient cold, with almost no increase in expense, to supply milk twenty-four to thirty-six hours old which will not contain in each cubic centimeter over 50,000 to 100,000 bacteria, and no milk containing more bacteria should be sold.

THE KIND OF BACTERIA FOUND IN THE MILK.

The kind of bacteria and the nature of the bacterial toxic products in milk are more important from a public health standpoint than the number per cubic centimeter. We made no detailed qualitative analysis of the milk samples, partly for lack of time and partly because it is possible by presumptive tests to determine whether a milk is contaminated with bacteria from manure, cow dung, and other outside sources. This is done by the fermentation of sugar broth.

It has been abundantly demonstrated (see reference to the literature, p. 80) that the bacteria in milk, as it leaves the udder, largely consist of staphylococci, streptococci, and other pyogenic organisms. None of these bacteria ferment sugar broth. On the other hand, the colon bacillus, including the entire group of lactic acid producers and many other organisms that gain entrance into the milk from cow dung, manure, dust, water, etc., cause active fermentation. We therefore possess a ready test for the approximate determination of the character and sources of the bacteria in milk. MacConkey states (see p. 80) that with ordinary care and cleanliness freshly drawn milk should not contain gas-forming organisms in 50 cubic centimeters.

We examined a number of samples of milk purchased upon the open market for the presence of gas-forming organisms in 0.1 cc., 1 cc., and 10 cc., and, as will be seen by the following table, practically all of them contained fermenting bacteria.

Fermentation in samples of milk purchased in Washington, D. C., in 1906.

Name.	Date.	Temperature of the milk.	Fermentation (gas production).			Remarks.
			0.1 cc.	1 cc.	10 cc.	
		° C.				
Anandale Dairy	Nov. 3	9.0	+	+	+	Sample obtained from the dairy.
Bellevue Dairy	Nov. 1	8.0	+	+	−	Do.
Belmont Dairy	Oct. 30	9.0	+	+	+	Do.
Chestnut Farm Dairy	Nov. 2	5.0	+	+	+	Do.
Chevy Chase Dairy	Nov. 10	11.0	−	−	+	Do.
Dulin's Dairy	Nov. 2	8.0	+	+	+	Do.
Evergreen Dairy	Oct. 31	13.0	+	+	+	Do.
Fairfax Dairy	Nov. 2	10.0	−	+	+	Do.
Farmer's Dairy	Oct. 31	11.0	−	+	+	Do.
Green Meadow Dairy	Nov. 5	10.0	+	+	+	Do.
Hartung's Dairy	Nov. 6	10.0	+	+	+	Do.
Hickory Hill Dairy	do	14.0	+	+	+	Do.
Hamilton Dairy	Nov. 1	8.0	+	+	+	Do.
Ingleside Dairy	do	9.0	+	+	+	Do.
Jersey Dairy	Nov. 5	11.0	+	+	+	Do.
Klondike Dairy	Oct. 31	11.0	+	+	+	Do.
Lewinsville Dairy	Nov. 10	13.0	+	+	+	Do.
Linden Dairy	Oct. 30	15.0	−	−	−	Do.
Mount Pleasant Dairy	Nov. 8	11.0	+	+	+	Do.
National and Aspen Grove Dairy	Oct. 30	14.0	−	−	+	Do.
Our Farm Dairy	Nov. 3	10.0	+	+	+	Do.
Pearl Dairy	Nov. 6	13.0	+	+	+	Do.
Sharon Dairy	Nov. 12	16.0	+	+	+	Do.
Shenandoah Dairy	Nov. 9	9.0	+	+	+	Do.
Spa Spring Dairy	do	11.0	−	+	+	Do.
Springdale Dairy	Nov. 2	7.0	+	+	+	Do.
Standard Dairy	Oct. 30	16.0	+	+	+	Do.
Swiss Dairy	Nov. 3	8.0	+	+	+	Do.
Thompson's Dairy	Nov. 9	12.0	+	+	+	Do.
Union Valley Dairy	Nov. 5	7.0	−	−	−	Do.
Walker-Gordon Laboratories	Oct. 30	8.5	−	−	+	Sample obtained from the wagon.
Do	Nov. 7	6.0	−	−	+	Do.
Do	Nov. 10	9.0	+	+	+	Do.

Examination of milk found on the market in the District of Columbia, August and September, 1906.

Name.	Date.	Samples obtained at—	Temperature of milk when obtained.	Number of bacteria per cubic centimeter.	Amount of foreign matter.	Curd at 37°C.	
			°C.				
Avondale Dairy, 146 C street NE	Aug. 30	Dairy	14.5	18,300,000	Little	Normal	
Bellevue Dairy, 1431 P street NW	Aug. 6	Wagon	18.0	1,380,000	None		
	Sept. 5	Dairy	8.0	166,600	do	Normal	
	do	Wagon	11.0	260,000	do	do	
Belmont Dairy, 2016 Fourteenth street NW.	Aug. 13	do	15.0	6,200,000	Much	do	
	Aug. 16	Dairy	12.0	3,600,000	Little	do	
	Sept. 10	731 Twenty-second street NW	12.0	5,400,000	do	do	
	Sept. 11	do	8.0	8,900,000	do	do	
	Sept. 12	do	7.0	5,200,000	Very little	do	
	Sept. 13	do	11.0	370,000	Little	do	Formalin.
	Sept. 14	do	17.0	8,700,000	do	do	
	Sept. 15	do	11.0	1,500,000	Much	Abnormal	
	Sept. 17	do	12.0	9,700,000	Little	Normal	
	Sept. 18	do	17.0	17,600,000	Very little	do	
	Sept. 19	do	21.0	69,600,000	Little	do	
	Sept. 20	do	19.0	7,900,000	do	do	
	Sept. 21	do	16.0	20,000,000	do	do	
Chestnut Farm Dairy, 1116 Connecticut avenue NW.	Aug. 13	Dairy	8.0	3	None	Abnormal	Pasteurized.
	Aug. 16	do	7.0	36,000	do	do	Do.
	Aug. 21	221 First street NW	9.0	17,200	do	Normal	Do.
	Aug. 22	do	8.0	190,000	do	Abnormal	Do.
	Aug. 23	do	11.0	64,000	do	Normal	Do.
	Aug. 24	do	11.0	42,000	do	do	Do.
Chevy Chase Dairy, 3310 P street NW	Aug. 13	1127 Thirteenth street NW	17.0	2,500,000	do	do	
	Aug. 20	Dairy	15.0	44,000,000	Much	do	
	Aug. 28	do	12.0	33,000,000	Little	do	
	Sept. 11	731 Twenty-second street NW	23.0	22,800,000	do	do	

	Sept. 12	do	22.0	9,870,000	do	do
	Sept. 13	do	20.0	10,700,000	do	do
	Sept. 14	do	21.0	7,400,000	do	do
	Sept. 15	do	15.0	1,010,000	Very little	Abnormal
	Sept. 17	do	19.0	550,000	do	Normal
	Sept. 18	do	22.0	11,000,000	Little	do
	Sept. 19	do	21.0	44,000,000	do	do
	Sept. 20	do	18.0	14,900,000	do	do
	Sept. 21	do	22.0	5,800,000	Very little	do
Clover Hill Dairy	Sept. 6	Wagon	11.0	4,860,000	None	do
C. E. Cornwell	Aug. 3	do	21.5	12,500,000	do	
Edw. M. Dulin, 1021 Twentieth street NW.	Aug. 13	do	15.0	11,200,000	do	Normal
	Sept. 25	Dairy	9.0	380,000	Little	do
Eckington Dairy, 123 Seaton street NE.	Aug. 2	Wagon	21.0	5,900,000	do	
Evergreen Dairy, 1300 Ninth street NW.	Aug. 8	do	15.0	9,200,000	None	
	Aug. 10	Hygenic Laboratory	16.0	45,900,000	Little	Normal
	Aug. 13	do	15.0	15,600,000	None	do
	Aug. 14	do	15.0	18,200,000	Little	do
	Aug. 15	do	15.0	8,400,000	do	do
	Aug. 16	do	17.0	2,500,000	None	do
	Aug. 17	do	16.0	6,800,000	Little	do
	Aug. 20	do	23.0	19,200,000	Little (hairs)	
	Aug. 22	Dairy	16.0	28,800,000	Little	Normal
Fairfax Dairy, 2012 H street NW	Aug. 20		13.0	2,400,000	None	do
	Aug. 21	Dairy	15.0	4,300,000	Very little	do
	Sept. 5	do	16.0	1,930,000	Little	do
Farmers' Dairy, 1406 Tenth street NW	Aug. 22		14.0	1,640,000	Much	do
	Sept. 25	Dairy	11.0	2,800,000	Little	do
Friendship Dairy Farm, Tenleytown, D. C.	Aug. 2	Wagon	24.0	220,000	do	
Glenmore Dairy, 1211 C street SW	Aug. 29	do		1,655,000	do	Normal
Green Meadow Dairy, 330 New York avenue NW.	Aug. 14	221 First street NW	20.0	27,000,000	do	do
	Aug. 15	do	17.0	36,600,000	None	do
	Aug. 16	do	16.0	4,000,000	Little	do
	Aug. 27	Dairy	15.0	11,300,000	do	do

Examination of milk found on the market in the District of Columbia, August and September, 1906—Continued.

Name.	Date.	Samples obtained at—	Temperature of milk when obtained.	Number of bacteria per cubic centimeter.	Amount of foreign matter.	Curd at 37°C.	
			°C.				
Hamilton Dairy, 1450 P street NW	Aug. 6	Wagon	22.0	1,800,000	None		
	Sept. 25	Dairy	11.0	2,500,000	Very little	Normal	
Hillsdale Farm, Bethesda, Md	Aug. 3	Wagon	24.0	42,000,000	None		
Hartung's Dairy, 108 Florida avenue NW	Aug. 28	do	15.0	50,400,000	Little	Abnormal	
	Aug. 31	Dairy	12.0	43,100,000	do	Normal	
Hickory Hill Farm, 2306 L street NW	Aug. 7	Wagon	22.0	4,200,000	None		
	Aug. 20	Dairy	23.0	5,300,000	Little	Normal	
	Aug. 21	do	18.0	6,600,000	do	do	
Ingleside Dairy, 1757 Pennsylvania avenue NW.	Aug. 13	do	15.5	27,600,000	do	do	
	Aug. 27	do	15.0	23,400,000	do	do	
	Aug. 29	Wagon	10.5	30,600,000	do	do	
	Aug. 30	do	12.0	53,400,000	do	do	Some fermentation.
Jersey Dairy. 460 K street NW	Aug. 13	Dairy	18.5	50,400,000	None	do	
	Aug. 19	221 First street NW	19.0	40,600,000	do	do	
	Aug. 15	do	21.0	5,700,000	Little	do	
	Aug. 16	do	15.0	30,600,000	do	do	
	Aug. 17	do	19.0	4,800,000	do		
Klondyke Dairy, 611 L street NW	Aug. 28	Wagon	16.0	65,820,000	None	Normal	
	Sept. 11	731 Twenty-second street NW	14.0	40,800,000	Little	do	
	Sept. 12	do	16.0	3,900,000	do	do	
	Sept. 13	do	18.0	1,415,000	do	do	
	Sept. 14	do	18.0	24,600,000	do	do	
Lewinsville Farm Dairy, 1708 Wisconsin avenue NW.	Aug. 22		22.0	2,400,000	do	do	
	Aug. 28		17.0	5,000,000	do	Abnormal	
Linden Dairy, 2021 Fourteenth street NW.	Aug. 16	Dairy	12.0	145,800,000	do	Normal	
	Sept. 25	do	10.0	3,100,000	do	do	
Mount Rocky Dairy, 211 Tenth street SW.	Aug. 29	Wagon	15.0	550,000	do	do	
	Sept. 26	Dairy	13.0	11,800,000	do	do	Do.

National and Aspen Grove Dairy, 616 O street NW.	Aug. 8	Wagon	21.0	55,200,000	....do		
	Aug. 10	Hygenic Laboratory	23.0	40,500,000	....do	Normal	
	Aug. 27	Dairy	18.0	43,800,000	....do	Abnormal	
	Sept. 8	731 Twenty-second street NW	11.0	3,300,000	....do	Normal	
	Sept. 10	....do	22.0	63,000,000	Very little	....do	Do.
	Sept. 11	....do	17.0	34,200,000	Little	....do	
	Sept. 12	....do	17.0	39,000,000	....do	....do	
	Sept. 13	....do	19.0	132,000,000	....do	....do	Cap on bottle very loose.
	Sept. 14	....do	20.0	63,600,000	....do	....do	
Nonpareil Dairy, 1121 Eleventh street NW.	Sept. 5	Wagon	10.0	2,900,000	....do	....do	
	Sept. 25	Dairy	12.0	660,000	....do	....do	
Our Farm Dairy, 107 Seventh street NE.	Aug. 30	....do	10.0	6,806,000	None	....do	
	Aug. 31	....do	9.0	17,000,000	....do	....do	
Pearl Dairy. 1828 Fourteenth street NW.	Aug. 16	....do	14.0	13,470,000	Little	....do	
	Aug. 23	Wagon	14.0	6,700,000	....do	....do	
	Aug. 29	....do	18.0	7,000,000	....do	....do	
Riverview Dairy, Conduit road, District of Columbia.	Aug. 3	....do	23.5	16,000,000	None		
Sharon Dairy, 324 B street SW	Aug. 2	....do	24.0	60,000,000	Little		
	Aug. 20	221 First street NW	24.0	307,800,000	None	Normal (?)	Gas production in 9½ hours.
	Aug. 21	....do	23.0	80,000,000	Little	Normal	
	Aug. 22	....do	24.0	4,000,000	....do	....do	
	Aug. 23	....do	24.0	1,000,000	....do	....do	
	Aug. 24	....do	19.0	9,800,000	....do	....do	
Spa Spring Dairy, 55 Rhode Island avenue NW.	Sept. 17	45 U street NW	13.0	4,400,000	....do		
	Sept. 18	....do	16.5	2,200,000	Very little	Normal	
	Sept. 19	....do	20.0	6,100,000	....do	....do	
	Sept. 20	....do	16.0	33,150,000	Little	....do	
	Sept. 21	....do	14.5	12,860,000	....do	....do	
Spring Dale Dairy (via Brooke & Harry), 720 Twentieth street NW.	July 31	Hygienic Laboratory	20.0	1,600,000	None		
	Aug. 6	Wagon	20.0	9,580,000	Little		
	Aug. 24	Dairy	20.0	2,100,000	Very little	Normal	
	Aug. 27	....do	12.0	9,000,000	None	....do	
Springfield Farm Dairy	Aug. 3	Wagon	12.0	260,000	....do		

Examination of milk found on the market in the District of Columbia, August and September, 1906—Continued.

Name.	Date.	Samples obtained at—	Temperature of milk when obtained.	Number of bacteria per cubic centimeter.	Amount of foreign matter.	Curd at 37°C.	
			°C.				
Standard Dairy, 1333 Fourteenth street NW.	Aug. 13	Dairy	9.0	56,400,000	Little	Normal	
	Aug. 16	....do	18.0	1,400,000	....do	....do	
	Sept. 11	731 Twenty-second street NW	12.0	43,200,000	Much	....do	
	Sept. 12	....do	14.0	34,200,000	Little	....do	
	Sept. 13	....do	13.0	49,200,000	....do	....do	
	Sept. 14	....do	19.0	30,600,000	....do	....do	
	Sept. 15	....do	14.0	13,200,000	Very little	....do	
	Sept. 17	....do	21.0	5,170,000	Little	....do	
	Sept. 18	....do	19.0	9,950,000	Very little	....do	
	Sept. 19	....do	24.0	15,200,000	Little	....do	
	Sept. 20	....do	22.0	62,400,000	....do	....do	Contained mouse(?) feces.
Sunnyside Dairy, 1232 Thirty-third street NW.	Aug. 8	Wagon	22.0	44,400,000	None		
Swiss Dairy, 403 East Capitol street	Aug 30	Dairy	9.0	14,000,000	Little	Normal	
	....do	Wagon	8.0	11,500,000	....do	....do	
	Aug. 31	Dairy	10.0	42,000,000	Much	....do	
	....do	Wagon	15.0	33,000,000	Little	....do	
Thompson's Dairy, 511 Four-and-a-half street SW.	Aug. 14	221 First street NW	17.0	1,300,000	....do	....do	
	Aug. 15	....do	15.0	2,400,000	None	....do	
	Aug. 16	....do	24.0	4,800,000	Little	....do	
	Aug. 17	....do	25.0	12,000,000	....do	....do	
	Aug. 24	....do	24.0	15,600,000	Very little	....do	
J. H. Trunnell, 1332 Thirty-third street NW.	Sept. 26	Dairy	13.0	420,000	Little	....do	
Union Valley Dairy, 300 I street NW	Aug. 23		12.0	13,400,000	....do	....do	
	Aug. 27	Dairy	13.0	28,200,000	Very little	....do	
Virginia Dairy, Conduit road, District of Columbia.	Aug. 8	Wagon	21.0	105,600,000	None		

Walker-Gordon Laboratories, 1020 Connecticut avenue NW.	Aug. 1	Hygienic Laboratory	18.0	400,000	do		
	Aug. 2	do	18.0	3,200,000	do		
	Aug. 3	do	19.0	520,000	do		
	Aug. 6	do	22.0	200,000	do		
	Aug. 7	do	21.0	290,000	do		
	Aug. 8	do	12.0	156,000	do		
	Aug. 9	do	15.0	40,000	do		
	Aug. 10	do	15.0	55,200	do		Coagulation and separation of whey after incubating 24 hours at 37° C.
	Aug. 11	do	16.0	41,000	do	Normal	
	Aug. 13	do	14.0	48,000	do	do	
	Aug. 14	do	14.0	39,000	do	Abnormal	Whey separated.
	Aug. 15	do	14.0	80,000	do	do	Do.
	Aug. 16	do	19.0	130,000	do	do	Whey separated (9.15 a. m.).
	do	do	19.0	134,000	do		Whey separated (4 p. m.).
	Aug. 17	do	14.0	73,000	Little	Abnormal	Whey separated.
	Aug. 20	do	23.0	108,000	do	do	Do.
	Aug. 21	do	18.0	196,000	None	do	Do.
	Aug. 28	do	16.0	86,000	do		
	do	do	16.0	84,000	do	Abnormal	Do.
	Sept. 26	Dairy	10.0	2,100,000	Little	Normal	
Walker-Hill Dairy, 530 Seventh street SE.	Aug. 20	221 First street NW	22.0	28,800,000	do	do	
	Aug. 21	do	24.0	238,000,000	do	Normal (?)	Curd in 6 hours.
	Aug. 22	do	23.0	63,000,000	do	Normal	
	Aug. 23	do	23.0	119,000,000	do	do	Sour in 9 hours.
	Aug. 24	do	22.0	201,000,000	Much	do	Sour in 6 hours.
Wayside Farm, Lewinsville, Va.	Aug. 2	Wagon	24.0	31,800,000	do		
Average			16.5	22,134,289			

NOTE.—All the samples curdled overnight in the incubator at 37° C.

The curd was considered "normal" if the coagulum was solid in this time; but "abnormal" if the milk curdled into small irregular lumps with marked separation of the whey. Sometimes "putrefaction" was indicated by fermentation of the curd. This condition is indicated.

In general our laboratory results confirm the conclusions arrived at from an inspection of the dairies and dairy farms that much of the milk sold in the District is old, warm, and dirty, is not handled with intelligent or proper care, and that unless this condition of affairs is corrected it must remain a menace to the public health, not only from the standpoint of typhoid fever, but also diphtheria, scarlet fever, summer complaints of children, tuberculosis, etc.

A REVIEW OF THE LITERATURE UPON THE BACTERIOLOGY OF MILK.

It is interesting to review the recent literature upon the number and kinds of bacteria found in milk to compare with our work. The following is taken largely from the excellent *referate* contained in "A contribution to the bacteriology of milk," by Alfred MacConkey, Lister Institute of Preventive Medicine, published in the Journal of Hygiene, volume 6, July, 1906, page 385; from Allgemeine Morphologie und Biologie der pathogenen Mikroorganismen by E. Gotschlich, in Kolle & Wassermann's Handbuch der pathogenen Mikroorganismen, 1st Bd., page 29; from Park's Pathogenic Microorganisms, including Bacteria and Protozoa, 1905; and from various other sources.

Sedgwick and Batchelder [a] (1892) found that, with moderate precautions on the part of the milker, the number of bacteria in fresh milk may not exceed 500 to 1,000 per cubic centimeter; but when the ordinary flaring milk pail is used, with more or less disturbance of the bedding and shaking of the udder, as many as 30,000 bacteria have been counted in 1 cc.

The fact that it is practically impossible, under ordinary conditions, to obtain milk uncontaminated with cowdung is believed by many. The constant presence of such pollution has been suggested by Park.[b] (1901).

Delépine [c] (1903) considers that it is even difficult to conceive how slight fecal pollution of cow's milk can be prevented under any circumstances.

Boekhout and de Vries [d] (1904) are of the same opinion.

MacConkey, however, finds that with ordinary care and cleanliness it is possible to obtain milk which when freshly drawn contains less than 1,500 organisms per cubic centimeter; and, further, that such milk should not contain gas-forming organisms in less than 50 cc.

Comparing these results with the work of others we find that Park

[a] Sedgwick and Batchelder. Boston Med. and Surg. Journ., 1892.

[b] Park, W. H. Journ. Hyg., vol. 1, p. 391.

[c] Delépine, S. Journ. Hyg., vol. 3, p. 68.

[d] Boekhout and de Vries. Centblt. f. Bakt., Abt. 2, Bd. 12, p. 89.

(1901) found the average bacterial content of the milk from six separate cows examined five hours after collection to be 6,000 per cubic centimeter, the lowest count being 400 per cubic centimeter, and of 25 cows of which the milk was tested immediately after drawn, it was 4,550.

Burr[a] (1902), also taking every reasonable precaution, found 500 organisms per cubic centimeter in the milk of a single cow.

Von Freudenreich[b] (1902) thought it would be easy to carry out strict asepsis and thus obtain a bacteria-free milk; but he soon came to the conclusion that this was impossible. He found that milk always contained 250 to 300 organisms per cubic centimeter, even though the milker's hands and the teats were washed first with soft soap and sterile water and then with servatol soap and sterile water, and finally with sterile water alone and dried on a sterile towel. The milker's hands were smeared with lanoline and the first milk rejected. The bacterial content of the mixed milk of 28 cows milked in this way varied from 65 to 680 organisms per cubic centimeter.

Freudenreich and Thoni,[c] from a further series of similar experiments, conclude that freshly drawn milk, even when the most careful precautions are taken against contamination, always contains bacteria; that these are mostly cocci and that they come from the udder.

Continuing his experiments von Freudenreich[d] (1903) states that he examined the udders and the milk in the udders of 15 cows in 13 cases immediately after slaughtering. He found none bacteria free. The organisms were mostly cocci. *B. lactis acidi* was met with once only. In three cases the ducts were diseased, and in these cases the diseased tissues contained fewer organisms than usual. *B. coli* was never found. He mentions that Boekhout and de Vries drew milk directly from the udder with a sterile canula and always got a growth from it.

Lux[e] (1904) examined milk drawn without aseptic precautions. Two hundred and sixty cow-milk and 95 goat-milk samples were analyzed. The average number of bacteria per cubic centimeter was 1,395, which were mostly nonpathogenic cocci.

Henderson[f] (1904) examined seven normal udders and obtained growth in 76 per cent of the cultures made, the organisms being staphylococci, streptococci, and pseudo-diptheria bacilli. No organisms were found pathogenic to laboratory animals.

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[a] Burr, Rollin H. Centlblt. f. bakt., Abt. 2, Bd. 8, p. 236.

[b] Freudenreich, Ed. von. Centlblt. f. bakt., Abt. 2, Bd. 8, p. 674.

[c] Freudenreich and Thoni. Centlblt. f. bakt., Abt. 2. Bd. 10, p. 305.

[d] Ibid., p. 401.

[e] Lux, A. Centlblt. f. bakt., Abt. 2, Bd. 11, p. 195.

[f] Henderson, J. Journ. roy. san. inst., vol. 25, p. 563.

Willem and Miele[a] (1905) obtained a milk containing 2.5 bacteria per cubic centimeter. The milking was done in a special place, which was kept as aseptic as possible. The greatest care was taken to insure the cows being clean. The udder and teats were washed before each milking with soap and boiled water or an aseptic solution.

From the examples quoted we see that it is practically impossible to obtain bacteria-free milk but that the organisms in carefully collected milk are not pathogenic to the usual laboratory animals. We may allow, then, that the presence of such organisms in reasonable number would not render a milk harmful to man. Lux's experiments have shown that with very ordinary care it is possible to obtain a milk containing on an average 1,400 bacteria per cubic centimeter and it is obvious that with very slight trouble the number may be much reduced.

The work of Park[b] (1901), Nicolle and Petit[c] (1903), Conn and Esten[d] (1904), Koning[e] (1905), F. C. Harrison[f] (1905), and others has shown that if milk be rapidly cooled to 11° C., or below, very little if any multiplication of organisms takes place for some twelve hours. Therefore Park's suggested average standard of not more than 12,000 bacteria per cubic centimeter in warm, and 5,000 per cubic centimeter, in cold weather for freshly drawn milk seems a generous standard and one which, with a little care, should be easily attained.

It is necessary to note that "separator milk" must not be judged by the same standard as fresh milk, for Severin and Budinoff[g] (1905) and Severin[h] have shown that, even when every possible precaution is taken against contamination, the milk issuing from the separator always contains many more bacteria than it did before it passed into the separating chamber. Severin suggests that the mechanical movement completes the separation of bacteria which were only partially divided when they entered the machine.

It may be of interest to mention that Jenson[i] (1903) states that the results of the Copenhagen Hygiene Commission showed that of 142 samples of pasteurized milk 98 samples contained more than 100,000 microbes per cubic centimeter.

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[a] Willem and Miele. Rev. gén. du Lait, p. 409. Ref.-Bull. de l'Inst. Pasteur, vol. 3, p. 725.

[b] Park, W. H. Journ. hyg., vol. 1, p. 391.

[c] Nicolle, C., and Petit, P. Revue méd. de Normand., Dec. 25, 1903. Ref.-Bull. de l'Inst. Pasteur, vol. 2, p. 552.

[d] Conn, H. W., and Esten, W. M. Reprints of studies from Rockefeller Institute for med. research., 1904.

[e] Koning. Centlblt. f. bakt., Abt. 2, Bd. 14, p. 424.

[f] Harrison, F. C. Centblt. f. bakt., Abt. 2, Bd. 14, p. 359.

[g] Severin, S., and Budinoff, L. Centblt. f. bakt., Abt., 2, Bd. 14, p. 463.

[h] Severin, S. Ibid, p. 605.

[i] Jensen, C. O. Ibid., p. 228.

Concerning the character of the organisms found in milk, most observers agree that, while bacteria are found almost constantly in milk, gas-forming organisms are practically never met with in milk drawn directly from the cow. For example, von Freudenreich (1902) expresses the opinion that in milk drawn directly into sterile tubes one usually finds only cocci present. Von Freudenreich and Thoni (1903) showed that lactic acid bacilli are not found in freshly drawn milk.

Further, von Freudenreich (1903) never found *B. coli* in the examination of 15 udders and milk in them.

Von Freudenreich (1904) never found *B. coli* or *B. lactis aerogenes* in the udder, and only one in milk taken directly into sterile glasses.

Lux (1904) found *B. coli* and *B. lactis aerogenes* taken together in 9 per cent of his samples. But he took no precautions as regards cleaning the udder.

Burr (1902) instituted several series of experiments to ascertain the source of the acid organisms of milk and cream. He took great care to have the stables, cows, and everything connected with them thoroughly clean. In milk drawn straight into test tubes he did not find lactic acid bacilli, but they were found in the cream of milk drawn into a sterile pail. Plates exposed under the cows for ten, twenty, thirty, and forty seconds during milking all contained *B. lactis aerogenes*, *B. acidi lactici* II, but no *B. acidi lactici* I. Tubes of sterile milk exposed about the barn and under the cows contained in nearly every case all the varieties of the bacilli mentioned, while milk taken at the same time direct from the udder did not contain any. He also examined the glandular part, the milk cistern, and the beginning of the teat of two udders, and failed to find any of these three bacilli.

He concludes that the lactic acid organisms, *B. lactis aerogenes*, *B. acidi lactici* II and I—the latter organism being the *B. acidi lactici* of Hüppe, Marpmann, and Esten—are a contamination from outside the udder. *B. acidi lactici* II and *B. lactis aerogenes* are commonly very abundant in the stable, while *B. acidi lactici* I, though almost universally present, exists in relatively small numbers.

Conn (1902) considers that the milk bacilli come seldom from the milk passages, but chiefly from sources distinct from the cow.

Harrison (1905) examined the milk of 25 cows. The udders and flanks were brushed and wiped with a damp cloth, the first milk was rejected, and the samples then taken in sterile test tubes. From the milk of two of these cows gas-producing bacteria were isolated. * * * He mentions that Moor and Ward have also isolated gas-producing bacilli from the udders of certain cows, but that it is evidently an exceptional state of affairs.

Savage [a] (1906) as the result of his investigations found that milk from individual cows yielded *B. coli* in 17.5 per cent of the samples. In 11 mixed milks collected fresh at the farm and examined within three hours *B. coli* was present in 36 per cent, and in 16 shop samples and mixed milk samples, not examined at once, they were present in 94 per cent of the samples.

Heinemann [b] (1905) considers that the lactic ferments are of intestinal origin and are present in milk owing to contamination with feces.

MacConkey further says that with ordinary care and cleanliness it is possible to obtain milk which, when freshly drawn, contains less than 1,500 organisms per cubic centimeter.

Freshly drawn milk should not contain gas-forming organisms in at least 50 cc.

Gas-forming organisms are present in milk owing to contamination with fecal matter. Of these organisms the *B. oxytocus perniciosus*, *B. neapolitanus*, and the *B. coli communis* occur in greatest number in fresh milk, while the *B. cloacae* and *B. lactis aerogenes* appear at a later stage.

Out of 107 nonchromogenic lactose fermenters isolated from milk only one bacillus gave the reactions of the *B. acidi lactici* (Hüppe), while the *B. Grünthal*, *B. pneumoniae* (Friedlander), and the *B. coscoroba* have not been met with once.

It seems, then, to be the general opinion that gas-forming bacteria are not normally present in milk, but that they gain access to it because of want of care and cleanliness during the milking and in connection with the various vessels in which the milk is stored. This opinion is quite borne out by the results of the experiments detailed in this paper.

Bergey [c] (1904) collected samples of milk drawn in sterile tubes directly from the udder of individual cows and showed that about one-third were free from bacteria, while only about 10 per cent of the samples contained large numbers—over 5,000 per cubic centimeter. The prevailing bacteria were pyogenic organisms, and when in large numbers were usually associated with inflammatory reactions in the udder. The organisms of putrefaction and the lactic acid bacteria gain access to the milk after it leaves the udder.

Bergey [d] (1904) also found the species of bacteria which appeared to be present in freshly drawn milk, such as staphylococci, strepto-

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[a] Savage, W. G., Journ. hyg., vol. 6, p. 123.

[b] Heinemann. Ref.-Bull. de l'Inst. Pasteur, vol. 4, p. 246.

[c] Bergey, D. H.: The cellular and bacterial content of cow's milk at different periods of lactation. Rpr. Univ. Pa. med. bull., July–Aug., 1904.

[d] Bergey, D. H.: Sanitary supervision of the collection and marketing of milk. Ibid.

cocci, and the bacillus of pseudodiphtheria. These are organisms which are concerned in the production of inflammatory reactions. The bacteria gaining access to the milk during milking and from various outside sources are the lactic acid bacteria and the putrefactive bacteria. The lactic acid bacteria, according to Bergey, consist of several varieties, such as *B. acidi lactici*, *B. lactis*, *M. acidi lactici*, and *B. coli communis*.

Park[a] found that milk taken from a number of cows in which almost no outside contamination had occurred contained, as a rule, very few bacteria, and these were streptocci, staphylococci, and other varieties of bacteria not often found in milk sold in New York City, the temperature at which milk is kept being less suitable for them than for bacteria which fall into the milk from dust, manure, etc.

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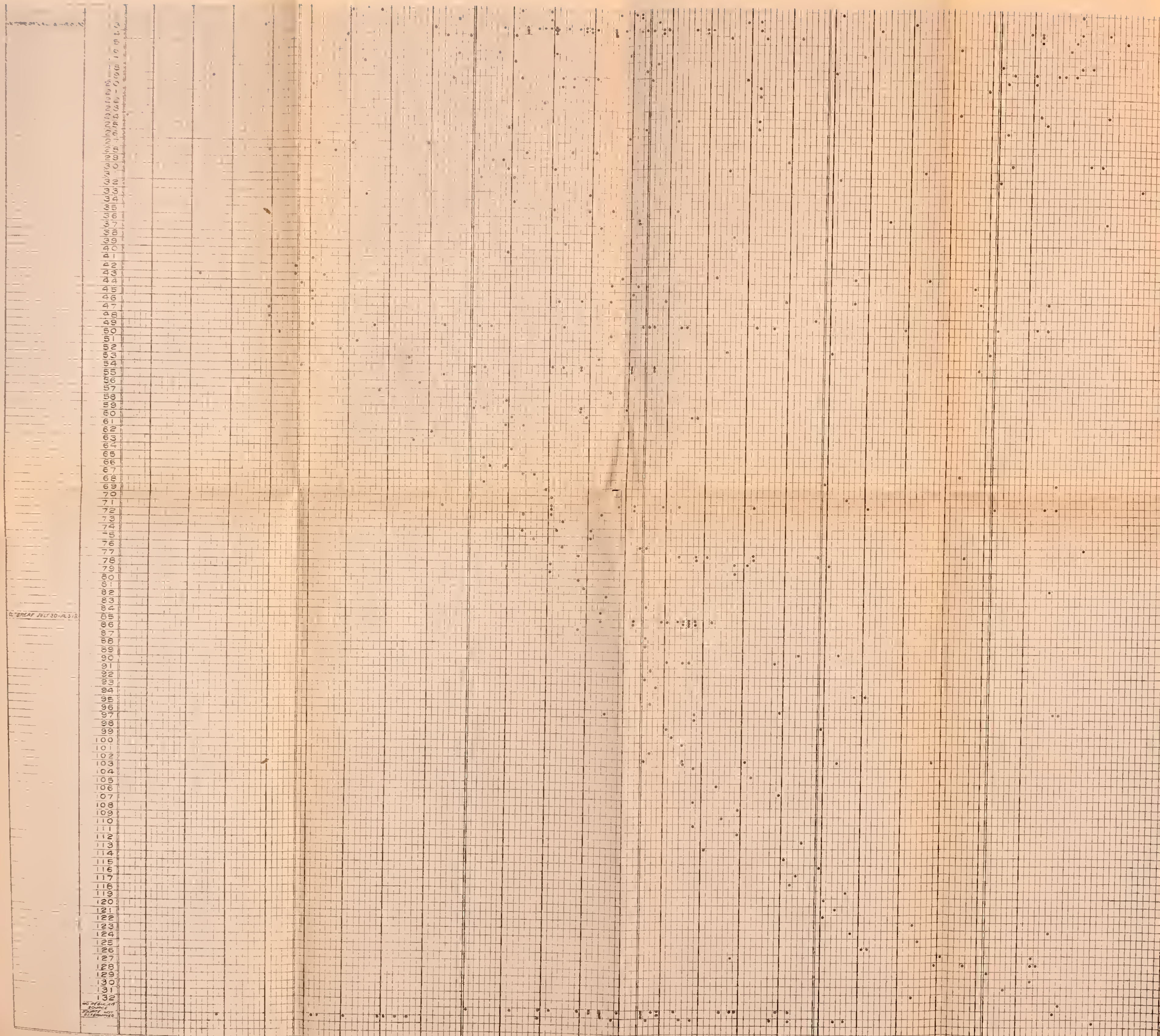
[a] Park, William Hallock: Pathogenic micro-organisms, including bacteria and protozoa; a practical manual for students, physicians, and health officers. New York, Lea Brothers & Co., 1905.

ONG CUSTOMERS OF TH

THE NORRIS PETERS CO., WASHINGTON, D. C.



3	44456	6.7	10
8	43800	18.2	11
5	39286	12.7	12
41	35995	113.9	13
7	31984	22.2	14
2	31542	6.3	15
4	29247	13.7	16
5	27247	18.4	17
7	24829	28.2	18
9	22005	40.9	19
4	14145	28.4	20
1	13909	7.2	21
1	12845	7.8	22
3	11617	25.8	23
3	11617	25.8	24
4	11304	35.4	25
1	11187	8.9	26
0	11070	0.	27
3	10836	27.8	28
			29
4	9697	41.2	30
4	9328	43.	31
1	8320	12.	32
1	7855	12.8	33
1	7723	12.9	34
4	6028	66.6	35
4	5225	76.9	36
1	3872	26.3	37
1	3182	31.2	38
1	3028	33.3	39
1	2168	47.6	40
0	1353	0.	41

NOTE: THESE RATIOS CALCULATED FOR THE MONTHS OF JULY, AUG., SEPT, AND OCT. ONLY.

SHOWING NUMBER OF CASES ACCORDING TO DATE OF ONSET AMONG CUSTOMERS OF THE PRINCIPAL MILK DEALERS IN THE DISTRICT OF COLUMBIA.

III.—ICE.

ICE.

Ice was not suspected of being a vehicle by which typhoid infection could be spread until it was shown in bacteriological laboratories that typhoid cultures are not killed by freezing.

Such diseases as dysentery and other more or less severe intestinal disorders, as well as typhoid fever, have at times been attributed to the use of impure ice. The question was therefore given special attention by us.

All the ice factories in the District of Columbia were inspected and samples of natural and manufactured ice examined bacteriologically and chemically. Similar analyses were made of all the well waters used by the ice factories in the manufacture of ice.

In the epidemiological part of our investigations the drinking of iced water and water obtained from melting ice was made one of the special inquiries in each of the 747 cases.

Five hundred and ninety-eight of the cases used ice in or for drinking water, in iced tea, etc.; 125 used no ice in foods or beverages. For 24 of the cases no definite statements regarding the use of ice were obtainable.

Our studies indicate that ice played little, if any, part in spreading the infection of typhoid fever in the District of Columbia. However, the inspection of the ice factories and the manner in which ice is handled disclosed several faults which should be corrected in order to insure a cleaner product and safeguard the public against the possibility of injurious contamination during the process of manufacture.

ICE AND TYPHOID FEVER.

Neufeld [a] (1903), in his article on typhoid fever, believes that the disease may undoubtedly be spread through the agency of ice, because the bacilli are resistant to cold.

Park [b] (1901) described an epidemic which was believed to have had its origin in ice obtained from a pond in which it was shown that the excrement from a patient sick with typhoid fever had been thrown while the pond was covered with ice.

[a] Neufeld, F.: Typhus. IX. Epidemiologie of Kolle & Wassermann's Handbuch der pathogenen Mikroorganismen, Bd. 2, p. 291.

[b] Park, W. H.: Virchow-Hirsch's Jahrsbericht für 1901, p. 16.

In the second annual report of the Board of Health of Connecticut for 1882 an interesting single case of typhoid fever is cited as probably derived from ice.

Dorange [a] (1898) described an epidemic of typhoid fever attributed to ice among 8 lieutenants in a regiment stationed at Rennes in the autumn of 1895. The implication of the ice in this instance rests upon a doubtful chain of evidence, however, and no mention is made of other possible factors.

Hutchins and Wheeler [b] (1903) report an epidemic of typhoid fever in the St. Lawrence State Hospital, 3 miles below Ogdensburg, N. Y., which seems to have been due to impure ice. The disease was endemic in the hospital for ten years, increasing from 2 cases with the opening of the hospital in 1890 to 40 cases in 1900. Although the water supply, tested bacteriologically and chemically, gave negative results, all observers agreed that the disease was water borne. In December, 1900, the source of the water supply was changed to the Oswegatchie River, a small Adirondack stream supplying Ogdensburg. This practically put a stop to the disease, for there were no cases of typhoid that were not clearly contracted elsewhere until October, 1902.

Following this eight persons were attacked, seven of whom were employees of the dining room. It seems the milk "could not have been infected." The water was excluded and other sources studied with negative results. The ice fell under suspicion; it had recently been taken from a newly opened ice house. The ice had been taken from the St. Lawrence at about the same spot as the ice previously used. It was gathered in February, and consequently had been stored for seven months. This ice disclosed a contamination of 30,400 bacteria per cubic centimeter on agar plates and 50,400 on gelatin. Of 8 fermentation tubes 3 showed evidence of organic contamination in the form of the colon bacillus.

The stock of ice was then examined. In the center of certain cakes were found foreign substances in the form of black or dark brown granular matter. Examined under the microscope this matter was found to be teeming with bacteria, from which both the colon and typhoid bacillus were isolated in pure culture.

With the discontinuance of the use of this infected ice the epidemic gradually subsided. There were in all 39 cases.

While it appears probable that milder intestinal diseases may be caused by ice highly polluted with decomposing organic matter, of

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[a] Dorange: Epidémie de fièvre typhoïde du à l'ingestion de glace impure. Rev. d'Hyg., vol. 20, 1898, p. 295.

[b] Hutchings, R. H., and Wheeler, A. W.: An epidemic of typhoid fever due to impure ice. Am. Journ. Med. Sci., vol. 126, 1903, p. 680.

which the Rye Beach epidemic, carefully studied by Nichols,[a] of Boston, in 1875, is a point in evidence, the case is different with typhoid fever. In only a few isolated instances has ice been accused of being the vehicle by which the infection of typhoid fever has been spread.

Sedgwick and Winslow[b] (1902), after reviewing the literature upon the subject of ice supply and public health, express the opinion that no epidemic of typhoid fever has been satisfactorily traced to such a source. They point out the fact that, while it is known that cultures of typhoid fever are not sterilized by freezing, the important question of the quantitative reduction of this species by freezing had been studied in only two limited investigations. They therefore froze large numbers of tubes inoculated with four different races of the typhoid bacillus and determined the reduction after various periods.

Sedgwick and Winslow draw the following poignant deductions: "Reviewing the several series of experiments described in detail, and keeping carefully in mind the conditions under which natural ice is formed, cut, harvested, stored, delivered, and finally consumed, as well as those pertaining to the manufacture, distribution, and consumption of artificial ice, certain conclusions appear to be justified concerning ice as a vehicle of disease, and these conclusions are, on the whole, decidedly reassuring.

"The conditions which tend naturally to purify polluted waters are now well understood. Light, cold, and pure-food supply are antiseptic or disinfectant agents of considerable power; hostile infusoria may devour the living germs of infectious disease; the chemical composition of the water may be unfavorable to their survival, and gravity may cause them to settle to the bottom, where they may soon perish for want of air. The main factor determining the reduction of germs in water is, however, the *time*—the time during which these and other forces are left to act. Epidemiology shows clearly that disease follows best a direct quick transfer of infectious material from patient to susceptible victim, and, if storage of water for some months could be insured, many sanitarians would consider such storage a sufficient purification.

"In ice we have this condition realized—a forced storage of at least

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[a] Nichols, A. H.: Report on an outbreak of intestinal disorder attributable to the contamination of drinking water by means of impure ice. Seventh Ann. Rep., S. B. H., Mass., 1876, p. 467.

[b] Sedgwick, W. T., and Winslow, C.-E. A.: Experiments on the effect of freezing and other low temperatures upon the viability of the bacillus of typhoid fever, with considerations regarding ice as a vehicle of infectious disease. 2. Statistical studies on the seasonal prevalence of typhoid fever in various countries and its relation to seasonal temperature. Mem. Am. Acad. Arts & Sci., vol. 12, no. 5, Aug., 1902. Summary, Boston Soc. Med. Sci., 1899–1900, v. 4, p. 181.

weeks and at best of many months. At the same time the other effective conditions are also heightened. It is no wonder, then, that our experiments show a reduction of over 99 per cent typhoid bacilli frozen, and we may be sure that in nature the destruction would exceed rather than fall short of such a limit.

"This reduction obtains in tubes which are frozen solid, where there is no chance for mechanical extrusion. In natural ice there is another purifying influence. Of the germs remaining in the water at the time of freezing, 90 per cent are thrown out by the physical phenomena of that process. This reduction is separate from and supplementary to the disinfecting action of the cold. Accordingly, when both factors work together it is obvious that only one out of a thousand typhoid germs present in a polluted stream has a chance of surviving in the ice.

"Under natural conditions the pathogenic germs present in the most highly polluted stream are comparatively few. Of these few one-tenth of 1 per cent may be present in ice derived therefrom. But even these scattered individuals are weakened by their sojourn under unfavorable conditions, so that, as we have seen, they require nearly twice as long for their development as do the normal germs, and these few and weakened germs very likely could not produce many, if any, cases of typhoid fever, for vitality and virulence in disease germs are probably closely related.

"With artificial ice the case is somewhat different, for such ice is made from water frozen solid and is as a rule quickly consumed. Artificial ice, if made from pure water, should be above reproach; but if it be made from water that is impure it may contain the germs of infectious disease; and inasmuch as artificial ice is used quickly after its manufacture, the possibility of purification by time is excluded, and such ice might therefore conceivably be a menace to the public health.

"With natural ice, as long as absolute sterilization is not effected, there must always remain a certain element of doubt, as in the case of sand filters alluded to above or in the practice of room disinfection after contagious diseases. The thickness of a layer of ice is often artificially increased by cutting holes in it and flooding that already formed with the water of the pond. In such a case the effects of crystallization are excluded, as in the laboratory tubes. Ice thus formed might be cut at once and served within a week or two, and in such an exceptional case we can not say that sufficient of the virus might not persist to excite the malady. Yet such an instance must be very exceptional, and the general result of human experience, the absence of epidemics of typhoid fever traced conclusively to ice, the fact that cities like New York, and Lowell and Lawrence in Massachusetts, have used the ice of polluted streams and have yet main-

tained low death rates from typhoid fever, all tend to support the conclusion at which we have arrived, namely, that natural ice can very rarely be a vehicle of typhoid fever."

We must admit the power of cold water and freezing to destroy large amounts of typhoid infection, but low temperatures alone can not be depended upon to remove the danger in infected water, especially when the infection is recent and concentrated. For example, we have the water-borne epidemic in Plymouth, Pa., in 1885, which began with the spring thaw. The outbreak in Ithaca, N. Y., started in epidemic proportions in January. The epidemic in Sherbourne, England, in 1873, likewise started in January. Four acute epidemic exacerbations are recorded in Philadelphia in December of the years 1884, 1890, 1899, and 1903. Several similar epidemics have occurred in the winter in Chicago—one in January, 1890, another in January, 1896, and one in March, 1891. Another striking instance is the epidemic in Newark, N. J., in February, 1899, and the one in December, 1891. Further, epidemics are recorded in Berlin in February, 1889, in Paris in February, 1894, and in Vienna in November, 1888. All of these are generally believed to have been water borne.

The occurrence of water-borne epidemics in the early spring, when the water is very cold and the conditions presumably unfavorable, is quite common.

INSPECTION OF THE ICE FACTORIES.

Passed Assistant Surgeon Baylis H. Earle, United States Public Health and Marine-Hospital Service, was detailed to make a sanitary inspection of the ice factories in the District, and makes the following report:

Fifteen factories and storerooms were inspected during the period between August 22 and September 11, 1906, as follows:

Ice factories of the District of Columbia.

HOME ICE COMPANY (INDEPENDENT), TWELFTH AND V STREETS NW.

Daily output.—Can system, 50 tons; plate system, 40 tons.

Water used.—Some city water; 3 driven wells, 60 feet deep; 2 dug wells, 36 feet deep.[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from engine; (2) grease separator; (3) condenser; (4) reboiler; (5) skimmer; (6) grease traps; (7) forecooler; (8) charcoal filters, containing also ground quartz (York Manufacturing Company, York, Pa.); (9) automatic fillers. Plate system: Quartz filters (?) claimed by owner, but think water is, as a rule, used direct from tap.

Wells, and locations of same.—Driven wells: (1) one under plate ice tank, 60 feet; (2) one under engine room, 60 feet; (3) one under fireroom, 60 feet; (4) one under office, 60 feet (not in use); (5) one at east end of loading platform, 240 feet (not successful). Dug wells: (1) One in "outside" stable, 36 feet, and (2) one in engine room, 36 feet. (Claims water from dug wells for condensing only.)

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[a] For condensing only (?).

Employees, water-closets, etc.—There are 30 persons, including clerks and drivers, employed about the factory, for whose use there are only two water-closets: (1) One on second floor over office, and (2) one on second floor adjoining engine room and near plate ice factory.

Horses, stables, etc.—Twenty-four horses, used for delivery of ice One stable inside building, being changed to ice storage room; one in yard and adjoining factory, having entrances on yard common to stable and factory.

HYGIENIC ICE COMPANY, FIFTEENTH AND E STREETS NE.

[Station No. 2 of the American Ice Company.]

Daily output.—Can system, 150 tons; plate system, 20 tons.

Water used.—Some city water, spring water, and seven driven wells, one 80 feet and six 200 feet.[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from engines; (2) grease separator; (3) condenser; (4) reboilers, three; (5) skimmers; (6) grease traps; (7) two old Loomis, two Hammond-Sashore's charcoal, and one sponge filter; (8) automatic fillers. Plate system: Raw, from spring.

Wells, and locations of same.—Driven wells: All in yard between factory and stable, fence and spring room (basement). One is 80 feet deep; the other six are each about 200 feet deep. Spring, with very large volume of water, opens from foot of hill in east end of (an old, dark, and muddy) unused basement room (full of trash, rotting wood, and even horse manure).

Employees, water-closets, etc.—There are 75 persons, including clerks and drivers, employed about the factory, for whose use there is only one water-closet, over the office. (Insufficient, and men use yard, hillside, basement, etc.—anywhere they can get cover, as by weeds. Human feces on board cover to deep well near door to spring room.)

Horses, stables, etc.—Fifty-one horses used for delivery of ice. Three stables in yard, between factory and hill, and very near seven driven wells and door to spring room. (Horse manure on and urine around board cover of nearest driven well.)

PURITY ICE COMPANY, BETWEEN K STREET, NAYLOR'S ALLEY, AND OLD CONVENTION HALL MARKET, NEAR FIFTH STREET NW.

[Columbia Ice Company controls output. In hands of receiver.]

Daily output.—Can system, 80 tons; plate system, 23 tons (April 1 to September 30, inclusive).

Water used.—City water; three driven wells, 120 feet deep.[a]

Processes, filtration, etc.—Can system—one side (old): (1) exhaust steam from engines; (2) grease separator; (3) Holman's patent condenser and coke filters; (4) reboilers; (5) skimmers; (6) grease traps; (7) two charcoal filters; (8) cans by automatic fillers. Other side (new): Same, except (3) cold water condensers. Plate system: Water through one large Loomis-Manning sand and gravel filter. (Latter is doubtful.)

Wells, and locations of same.—Driven wells: (1) Two under engine room, 120 feet deep; (2) two under boiler room, 120 feet deep (one of these not in use). Dug wells: One in fire room, 30 feet deep (not in use, supply insufficient).

Employees, water-closets, etc.—There are 28 persons (no clerks and drivers) employed about the factory, for whose use there is one water-closet with one hole in engine room. Other persons must use market closets in old Convention Hall across the alley, which is in very unhygienic condition.

Horses, stables, etc.—No horses or stables, as output is controlled by Columbia Ice Company. However, many horses in alley between market and factory; also garbage and other refuse from the market.

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[a] For condensing only (?).

CRYSTAL PLATE ICE COMPANY, THIRTY-FIFTH AND K STREETS NW. (GEORGETOWN).

[American Ice Company controls output.]

Daily output.—Can system, 50 tons (May 1 to October 1); plate system, 35 tons (year around).

Water used.—City water; canal water (condensers and water wheel) (one-half power steam and one-half water).[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from the engines; (2) grease separator; (3) condenser; (4) reboilers; (5) skimmers; (6) grease traps; (7) three Frick filters, tandem, and two New York Manufacturing Company's filters, and (8) cans by automatic fillers. Plate system: Raw, from city main.

Wells, and locations of same.—Driven wells: Two 40-foot wells were driven in present building, but water was too warm for condensing and they were abandoned.

Employees, water-closets, etc.—There are 15 persons (no drivers) employed about the factory, for whose use there are two privies, built over the river, about 150 feet from front of factory.

Horses, stables, etc.—No horses or stables, as output is controlled by American Ice Company. However, horses and wagons stand in front and there is much horse manure and urine on the street.

GEORGETOWN ICE COMPANY, 3327, 3329, 3331 K STREET NW. (GEORGETOWN).

[American Ice Company controls output.]

Daily output.—Plate system only, 20 tons (23 tons in winter).

Water used.—City water; canal water (condensers and water wheel).[a] Water power only.

Processes, filtration, etc.—Plate system: Raw, from city mains (used to filter, but not since installation of city filtration plant).

Wells, and locations of same.—Driven wells: One driven 80 feet, but could get no water—solid rock at that depth. Located in engine room.[b]

Employees, water-closets, etc.—There are 5 persons on regular duty, and 1 extra in cases of emergency, for whose use there is one privy over wheel pit on second floor; discharges into tail race, which empties into river.

Horses, stables, etc.—No horses or stables, as output is controlled by American Ice Company. However, horses and wagons stand in front, and there is much horse manure and urine on the street.

STATION NO. 3 OF THE AMERICAN ICE COMPANY, CORNER OF GRACE AND POTOMAC STREETS NW. (GEORGETOWN).

Daily output.—Plate system only, 30 tons (45 tons in winter).

Water used.—City water; canal water (condensers and water wheel).[a] Water power only.

Processes, filtration, etc.—Plate system: (1) City water through three large crushed flint filters; (2) forecooler; (3) one sponge cooler; (4) storage tank (well covered). Three flint filters and one sponge filter work tandem.

Wells, and locations of same.—None.

Employees, water-closets, etc.—There are 8 persons (no drivers) employed about the factory, for whose use there is one privy, having one hole; place, outside and back of factory over the fore bay of the flour mill just below.

Horses, stables, etc.—No horses or stables, as output is controlled by American Ice Company. However, horses and wagons stand in front and there is much horse manure and urine on the street.

---

[a] For condensing only (?).

[b] Failures.

THE A. LOFFLER SAUSAGE AND PROVISION COMPANY (INDEPENDENT), 3830 BRIGHTWOOD AVENUE NW.

[Cold storage plant. Cold air used. Only 5 tons of ice.]

Daily output.—Can system only, 5 tons.

Water used.—City water; one dug well (condensers), 16 feet deep.[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from engines; (2) grease separator; (3) condenser; (4) reboilers; (5) skimmers; (6) grease traps; (7) cooler; (8) forecooler; (9) filters, and (10) cans by automatic fillers. (Salt brine and anhydrous ammonia used.)

Wells, and locations of same.—Dug wells: One dug well, under boiler house, 16 feet deep.

Employees, water-closets, etc.—There are 35 persons, including clerks and drivers, employed about the factory, for whose use there are three water-closets, two between residence and factory and one between engine room of latter and barn.

Horses, stables, etc.—Fifteen horses used in connection with meat plant, which is the main part of this factory. Sell only a few tons of ice. Two stables in yard near ice factory. Manure said to be hauled away daily.

WASHINGTON MARKET COMPANY (INDEPENDENT), B STREET, BETWEEN SEVENTH AND NINTH STREETS, NW.

Daily output.—Can system only, 20 tons.

Water used.—City water; two driven wells, one 83 feet, the other 42 feet.[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from engines; (2) grease separator; (3) condenser; (4) reboilers; (5) skimmers; (6) grease traps; (7) cooler; (8) two large charcoal filters (York Manufacturing Company, York, Pa.); (9) storage tank and forecooler, and (10) cans by automatic fillers.

Wells, and locations of same.—Driven wells: One in yard, near Seventh street wing, 83 feet deep, and one in yard near its center, 42 feet deep.

Employees, water-closets, etc.—There are 6 persons employed to attend to the making and pulling of ice, for whose use there is one water-closet, with seven seats, and a trough urinal, opening on the yard.

Horses, stables, etc.—No horses stabled near market, but many wagons are brought there daily, so that the yard and surrounding streets are about as bad as or worse than a stable.

NICHOLAS AUTH PROVISION COMPANY (INDEPENDENT), SEVENTH STREET AND VIRGINIA AVENUE SW.

Daily output.—Can system only, 15 tons (except January, February, and December of each year).

Water used.—City water; three driven wells, one 30 feet, one 220 feet, and one 65 feet.[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from engines; (2) grease separator; (3) condenser; (4) reboiler; (5) skimmer; (6) grease and oil traps; (7) cooler; (8) two large charcoal filters (Vilter Manufacturing Company, Milwaukee, Wis.); (9) storage tank and forecooler, and (10) cans by automatic filler.

Wells, and locations of same.—Driven wells: One, midway under building, 30 feet deep; one, midway under building, 220 feet deep, and one in yard, 65 feet deep.

Employees, water-closets, etc.—There are 6 persons employed to attend to the making and pulling of ice, but 60 are employed on the premises. For all of these there are two water-closets upstairs, two first floor, and one basement, and there is one concrete-floor urinal.

[a] For condensing only (?).

Horses, stables, etc.—Twenty-eight horses used in connection with meat plant, which is the main part of this factory. Sell only a few tons of ice. Stables at corner of Sixth street and Virginia avenue SW., a large house intervening between them and the factory. Manure hauled away twice a week.

CHAPIN-SACKS MANUFACTURING COMPANY, FIRST AND M STREETS NE.

[American Ice Company controls output.]

Daily output.—Plate system only, 200 to 240 tons.

Water used.—City water only.

Processes, filtration, etc.—Plate system: (1) forecooler, and (2) one large Scaife filter.

Wells, and locations of same.—Driven wells: Four on premises, from 190 to 208 feet deep, but flow of water was too small for practical uses, so they were abandoned.

Employees, water-closets, etc.—There are 40 persons employed to attend to the making and pulling of ice, but there are 65 altogether on the premises, for whom there are one water-closet, stable; one water-closet, boiler house; one water-closet, first floor; one water-closet, second floor, and one water-closet, third floor—all for men; and one water-closet, first floor, for women.

Horses, stables, etc.—Fourteen to 15 horses used for delivery of ice and ice cream, Several large stables (others for horses in addition to the ice factory's horses) across Patterson street, which are kept in good condition.

CHAS. JAVINS & SONS (INDEPENDENT), 930 C STREET NW.

Daily output.—Can system only, 3 to 5 tons. (Ice made for own use; cold storage.)

Water used.—City water; two driven wells, one 3-inch and one 6-inch—both 40 feet deep.[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from engines; (2) grease separator; (3) condenser; (4) reboiler; (5) skimmer; (6) grease and oil traps; (7) forecooler; (8) two charcoal filters (Frick & Co.'s); (9) cooling storage tanks, and (10) cans by automatic filler.

Wells, and locations of same.—Driven wells: Two under engine room, both 40 feet deep, one 3-inch and one 6-inch.

Employees, water-closets, etc.—There are 6 persons employed to attend to the making and pulling of ice, but there are a number of others connected with the meat, shellfish, and vegetable cold storage business, for all of whom there are only two water-closets on second floor over engine room.

Horses, stables, etc.—None connected with this place, but many in the street just outside and in vacant lots near by, so that they are as bad as or worse than stables.

CORBY MANUFACTURING COMPANY (INDEPENDENT), LANGDON, D. C.

Daily output.—Can system only, 15 to 16 tons.

Water used.—City water; 5 driven wells, 60 to 85 feet deep; 1 spring.[a]

Processes, filtration, etc.—Can system: (1) Exhaust steam from engines; (2) grease separator; (3) condenser; (4) reboiler; (5) skimmer; (6) double pipe forecooler; (7) two charcoal filters (York Manufacturing Company, York, Pa.); (8) one charcoal deodorizer (De La Vergue Company, New York); (9) cooling storage tank, and (10) cans by automatic fillers.

Wells, and locations of same.—Driven wells: One, near factory, 85 feet; one, same, 81 feet; two,[b] farther from factory, 60 to 70 feet; and one,[b] farthest from factory, 64 feet. All except first near woods. Spring[c] at foot of hill—dry when wells in use.

Employees, water-closets, etc.—There are 6 persons employed to attend to the making and pulling of ice, but there are 12 to 18 on the immediate premises, for all of whom

[a] For condensing only (?).

[b] Not in use.

there is only one water-closet, containing six seats and four urinals, and so inconveniently placed that the ice men frequently use the woods near the wells and above the spring.

Horses, stables, etc.—None connected with this plant.

CHRISTIAN HEURICH (INDEPENDENT), BETWEEN WATER AND D STREETS, TWENTY-FIFTH AND TWENTY-SIXTH STREETS NW.

Daily output.—Can system, 120 tons; plate system, 50 tons.

Water used.—City water; Potomac River water (for condensers).

Processes, filtration, etc.—Can system: (1) Exhaust steam from engines; (2) grease separator; (3) condenser; (4) reboiler; (5) skimmer; (6) forecooler; (7) two coke and four charcoal filters; (8) cooling storage tank, and (9) cans by automatic filler. Plate system: City water through three Loomis-Manning sand and gravel filters.

Wells, and locations of same.—None.

Employees, water-closets, etc.—There are 44 persons employed to attend to the making and pulling of ice, for whom there is one water-closet across the yard. There are numerous other persons on the premises—connected with the brewery—for whom there are two more closets.

Horses, stables, etc.—Twenty horses, for delivery of ice, and 38 connected with brewery. The stables are at Twenty-sixth and E streets NW., but the horses stand in the yard and around the building all day, so that the conditions in the yard and surrounding streets are as bad as in a stable. Superintendent very discourteous.

COLUMBIA ICE COMPANY (INDEPENDENT), BETWEEN M STREET, NAYLOR'S ALLEY, AND OLD CONVENTION HALL, NW.

[Storage altogether; makes no ice. Controls Purity Ice Company's output.]

Daily output.—Does not manufacture ice, but controls Purity Company's output.

Water used.—See Purity Ice Company above.

Processes, filtration, etc.—See Purity Ice Company above.

Wells, and locations of same.—See Purity Ice Company above.

Employees, water-closets, etc.—A considerable number.

Horses, stables, etc.—Keep number of horses at stables on M street, some distance from office. However, many horses in alley between market and storeroom; also garbage and other refuse from the market.

STATION NO. 5 OF THE AMERICAN ICE COMPANY, THIRTY-FIRST AND K STREETS NW. (GEORGETOWN).

Daily output.—Does not manufacture ice, but stores it during winter months.

Water used.—See Georgetown factories above.

Processes, filtration, etc.—See Georgetown factories above.

Wells, and locations of same.—See Georgetown factories above.

Employees, water-closets, etc.—A large number.

Horses, stables, etc.—Keep large number of horses in stables opposite office and storerooms. Much horse manure lying about yard.

The factories named had a daily output each of 5 to 200 tons, the American Ice Company controlling that of five, the Columbia Ice Company that of one, the others being independent. It is understood that many of the large hotels, restaurants, and cold-storage plants have their own ice plants. As time was limited and it was ascertained that the ice manufactured by them was for their own use, no attempt was made to find or inspect them.

Some difficulties were encountered through discourtesy of employees and unwillingness of those in immediate charge to answer questions or to allow examinations of the plants, so that this report is not as thorough as it would be desirable to make it. However, all the factories found were eventually gone through from the boiler and engine rooms on the lowest floor to the condensers and reboilers on the roof.

Some of the plants had the can system only, some the plate system only, and others both systems. Two had modifications of the plate system, known as the "block system." The majority of them use the city water, a few use deep well water, and one uses spring water. In all cases it is claimed the water for the can system is obtained by condensation of the exhaust steam from the engines, which is first passed through a grease separator. After condensation it is reboiled to rid it of air as far as possible, during which process it is also automatically skimmed to eliminate any remaining grease. It is then carried through cooling pipes to charcoal or other filters and deodorized, and finally to the storage tanks, from which it is transferred to the cans when needed by means of automatic fillers.

In most cases the water for the plate system is taken direct from the general water supply, but in a few cases it is said to be filtered.

In no cases were the sanitary conditions as good as could be desired, and in some they were positively bad. In one place the can ice room had opening into it a window from a very filthy and ill-smelling urinal room, which at once attracted attention. On closer examination it was found that this small wash and urinal room had opening on to it from the four sides (1) the window from the can ice-making room, through which the urinal room is usually ventilated, (2) a meat and sausage cold-storage room, (3) the men's dressing room, and (4) the meat and sausage sorting and distributing room. The floor of this room is made up of concrete graded down to a hole at one side of the center. Water trickles down the nearest wall continuously and flows through the hole in the floor. The men stand on this urine-soaked floor and urinate thereon or against the wall. A wash basin in the corner, having running water, was very dirty and looked as though it had never been cleaned. The men's dressing room, which communicates with this urinal room by a very large doorway, was indescribably filthy. Badly soiled and blood-stained clothes littered the floor, while small pieces of meat, blood stains, and expectoration attracted large numbers of flies, which were simply swarming. The entire place—urinal and dressing room—was very foul smelling. While standing there it was noticed that meat and sausages were being carried in open boxes on low trucks through the urinal room and over the urine-soaked floor from the cold-storage room to the sorting and distributing room opposite. As the water falls on the

floor it is probable that the resulting spray is thrown upon the meat as it is carried through. The accompanying diagram A will give some idea of the conditions at this place:

In another factory the water used for ice making is taken from a spring which opens into a large unused basement room, and the water for condensing is obtained from seven driven wells in the narrow yard between the stable and the factory. This yard was grown up with weeds. The board cover of the deep well nearest the stable was covered with horse manure and surrounded by horse urine. The board cover of the well nearest the open door of the very insanitary basement room into which the spring opens was covered with newly deposited human feces, which was also noticed in the weeds nearby.

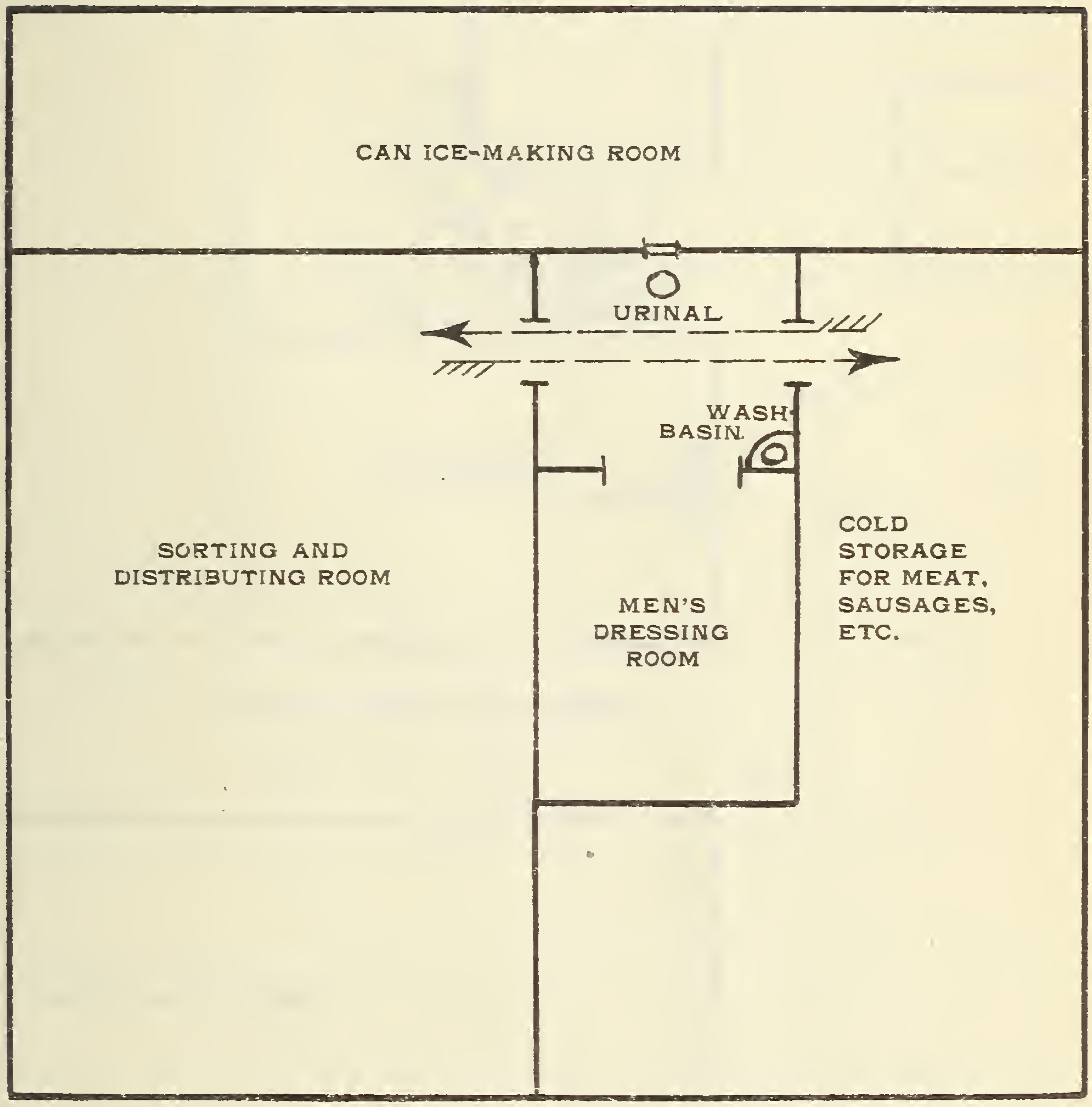
The floor of the spring room is the lowest place in the neighborhood and is covered with trash, rotting wood, mud, and the washings (by rain) from the surrounding inhabited hillsides. The spring is covered by a rusty, ill-fitting, iron door, one of the hinges of which was broken. On my second visit, just after a heavy rain, the water in this room was so deep that it was not possible to reach the spring; and it was noticed that horse manure and probably human feces had been washed into the room. My conductor informed me that during the rain this water had flowed over the edges into the spring, its rim being somewhat above the level of the floor.

The accompanying diagram B will give some idea of the conditions found:

In a third place the use of a very filthy, undrained, and ill-smelling stable in the center of the factory building had just been discontinued, and was being converted into an ice-storage room. A new, but undrained, stable had been erected near by. The board cover of a dug well in the corner of this stable, the water from which was said to be used for condensing, was covered with horse manure and surrounded by pools of horse urine. The yard between the stable and the factory was grown up with weeds, covered with horse droppings, very muddy and undrained at the time of inspection.

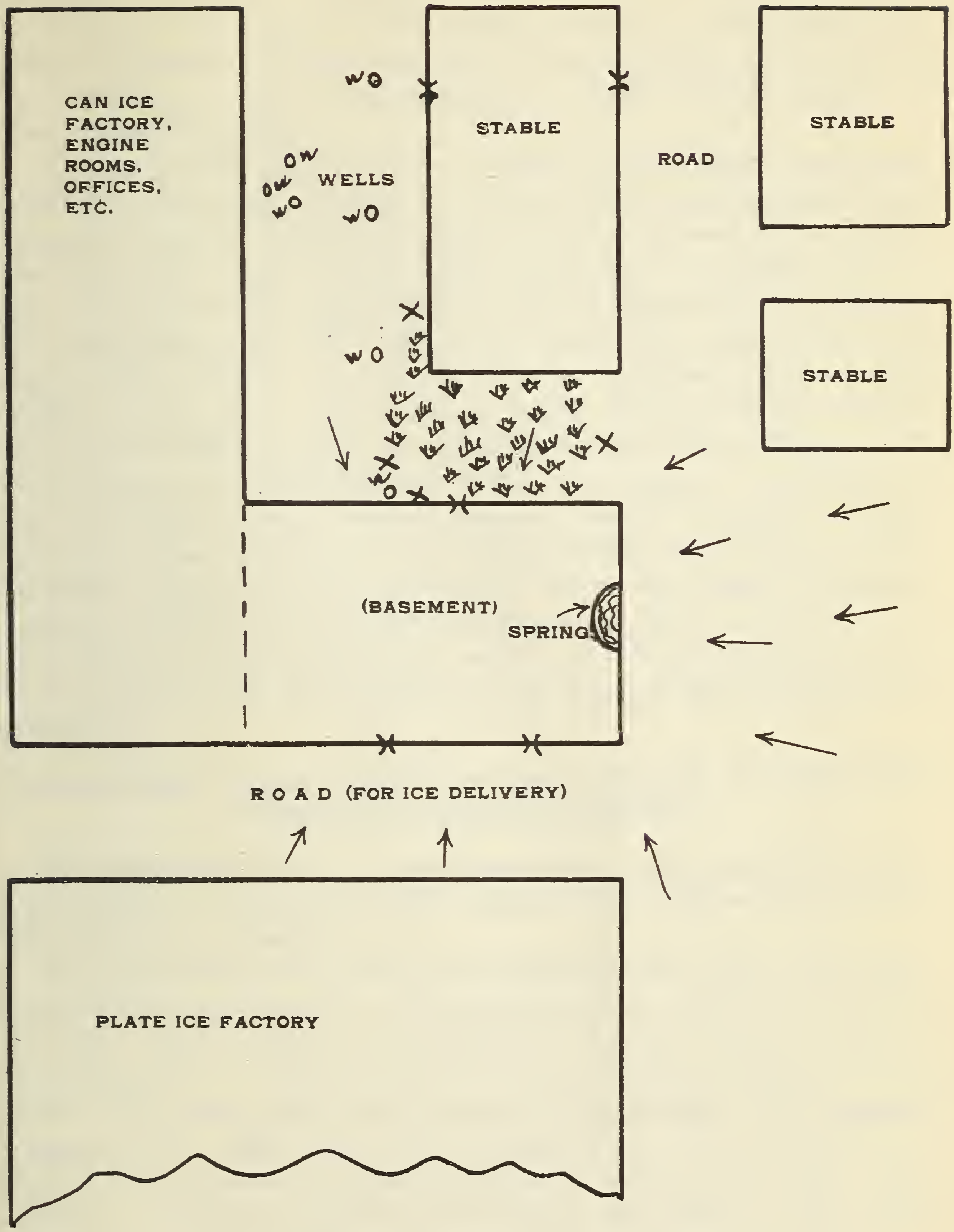
In many cases it was found that the wooden tops over the cans were dirty; that the cans and tanks are seldom if ever cleaned; that the men walk over the tops after visiting the yards, stables, urinals, etc., bringing in filth or dirt on their shoes; that water-closets are insufficient in number, inconvenient in place, and seldom if ever cleaned, and often times the men who work "on ice" must stand in urine to urinate; that there are many uncleaned and unused rooms adjoining ice-making or storage rooms, and unkempt, weed-grown yards nearby, in which men may urinate or defecate; that the men are uncleanly in their habits and clothing—one was seen to blow his nose through his fingers onto the wooden tops over the cans, and all wore old and badly soiled clothing and shoes; that the filters

DIAGRAM A.



ARROWS INDICATE COURSE OF MEAT IN OPEN BOXES OR LOW TRUCKS OVER URINE-SOAKED FLOOR. (SEE PAGE 100)

DIAGRAM B. (See Page 100.)



⋈ = Doors.

X ✓ = Weeds, Feces, Etc.

→ = Direction of Surface Water Flow, Showing Drainage to Spring.

O = Wells.

are seldom if ever cleaned and are of doubtful value from a bacteriological standpoint; that filthy water-closets and urinal rooms are very near, or opening on the ice-making rooms; and that stable and places for harnessed horses are close to the factories and wells, the men working on ice having frequently to walk through manure or fresh horse droppings.

It is suggested that the cans, wooden covers, tanks, and filters should be thoroughly cleaned at certain stated intervals and often enough to insure cleanliness; that no one be allowed on or about the cans and tanks except those necessary to handle them or the ice; that those employed to make or handle ice be required to wear clean suits and slippers or shoes, kept clean and worn only while working "on ice," and never to water-closets, urinals, stables, yards, etc.; that dressing rooms, with lavatories, adjoining the ice-making rooms, be furnished for the men working on ice; that better and sufficient water closets be furnished, convenient to the ice-making rooms; that all unused rooms be properly cleaned and then closed; that yards and hillsides nearby be cleared of weeds, penalties being imposed for urinating or defecating therein or thereon; that all stables, water-closets, urinals, etc., be so arranged as to diminish the danger of dragging manure or infection to the ice; and that only water of good quality be used for making either can or plate ice.

LABORATORY EXAMINATIONS OF ICE AND THE WATERS FROM WHICH ICE IS MANUFACTURED.

The specimens of ice for these examinations were purchased on the open market, sometimes from the wagon and sometimes directly from the storehouse or factory.

The specimens were handled with sterilized tongs, then thoroughly washed with sterile water, and finally placed in sterilized receptacles to melt, which action was facilitated by the aid of gentle heat not exceeding 40° C. As soon as the ice was melted samples of the water, while still cold, were taken for bacteriological and chemical examinations. The water thus obtained from the ice usually contained little particles of straw, splinters of wood, and "dirt," some of which sometimes adhered tenaciously to the surface, while others were found to be embedded throughout the substance of the ice.

It is interesting to note that from the specimens examined both the natural ice and the manufactured ice contained practically the same average number of bacteria per cubic centimeter; but the colon bacillus was encountered nearly twice as frequently (50 per cent as against 28.7 per cent) in the natural specimens as in manufactured ice.

It is further very interesting to note that the colon bacillus was not encountered in the 7 specimens of "can" ice examined, whereas

it was found in 30 per cent of the specimens of "plate" ice examined. This corresponds to the fact that can ice is almost invariably made from distilled water, whereas plate ice is made from river or well water unsterilized.

BACTERIOLOGICAL SUMMARY OF ICE EXAMINATIONS.

Number of specimens examined:	
Natural ice	6
Artificial ice	28
Total	34
Average number of bacteria per cubic centimeter:	
In natural ice	118
In artificial ice	123
Percentage of specimens of natural ice containing *B. coli:*	Per cent.
In 1 cc	16.6
In 10 cc	33.3
Total	49.9
Percentage of specimens of artificial ice containing *B. coli:*	Per cent.
In 1 cc	14.3
In 10 cc	14.3
Total	28.6
	Bacteria per cubic centimeter.
Average of 9 plate-ice specimens	216
Percentage of plate-ice specimens containing *B. coli:*	Per cent.
In 1 cc	20
In 10 cc	10
Total	30
	Bacteria per cubic centimeter.
Average of 7 can-ice specimens	18
Percentage of all can-ice specimens containing *B. coli:*	Per cent.
In 1 cc	0
In 10 cc	0
Total	0

NOTE.—In making the above average counts, ice specimen No. 29, which gave the unusual number of 5,000 bacteria per cubic centimeter, was not included; it was, however, included in the percentages of specimens containing *B. coli.*

Our examinations show for the most part that manufactured ice contains more bacteria than the water from which it has been frozen. The contrary of course should be the case, for it is now well known that the act of freezing causes the death of a large number of bacteria. This discrepancy, we believe, is readily accounted for by the unclean methods used in the manufacture of ice, given in detail in the report on the inspection of ice factories (p. 93). The added dirt accounts for the increased number of bacteria in the ice.

Results of bacteriological and chemical examination of wells and springs used by the ice factories.

No. of sample.	Location.	Date.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
	Home Ice Co., Twelfth and V streets NW.:					
238	Drinking well	Sept. 5	None.	Slight oily	None.	Very slight.
239	Condensing well	....do...	None.	None	Slight.	Slight, light brown.
240	Boiler room	....do...	None.	Slight oily	None.	Very slight, dark brown.
241	Under engine room	....do...	None.	.....do	None.	Very slight.
	Hygienic Ice Co., Fifteenth and E streets NE.:					
251	Under shed	Sept. 7	2	Suggestion of manure.	1	Slight, coarse light brown.
252	Gr. I, well 2	....do...	3	Slight, suggestion of manure.	6	Very slight.
253	Gr. I, well 3	....do...	(a)	.....do	55	Slight, light brown.
254	Gr. II, well 1	....do...	3	Suggestion of manure.	95	Slight, brown.
255	Gr. II, well 2	....do...	4	.....do	2	Slight, feathery.
256	Gr. II, well 3	....do...	3	.....do	2	Slight, light brown.
257	Gr. II, well 4	....do...	3	.....do	1	Do.
258	Spring	....do...	3	Slight, unpleasant	None.	None.
227	Spring	Aug. 31	....	....	....	
295	Corby Co., Langdon D. C.	Sept. 18	4	None	5	Slight.
	Purity Ice Co., Fifth Street Market NW.:					
271	Well 1	Sept. 12	2	Slight, unpleasant	1	Slight, light brown.
272	Well 2	....do...	2	Slight suggestion of sulphur.	None.	Very slight, yellowish.
273	Well 3	....do...	2	.....do	None.	Light brown.
	Auth Provision Co., Seventh street and Virginia avenue SW.:					
265	Well 1, 60 feet	Sept. 11	3	Slight, inky	55	Slight, light brown.
266	Well 2, 39 feet	....do...	3	Slight	None.	None.
268	Chas. Javins & Sons, 930 C street NW.	....do...	2	.....do	13	Do.
267	Center Market, Seventh street NW.	....do...	4	Slight, inky	600	Considerable iron oxide.

[a] Yellow-brown.

Results of bacteriological and chemical examination of wells and springs used by the ice factories—Continued.

No. of sample.	Location.	Total solids. Total residue.	Mineral matter.	Volatile matter.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitrites.	Nitrates.	Dissolved oxygen.	Oxygen consumed.
	Home Ice Co., Twelfth and V streets NW.:										
238	Drinking well	280	184	96	43.5	0.008	0.020	0.0001	5.00	9.89	2.2
239	Condensing well	228	162	66	38.0	.328	.016	.0600	.75	6.11	2.7
240	Boiler room	220	144	76	27.5	.008	None.	.0005	6.25	10.23	2.7
241	Under engine room	176	126	50	21.5	None.	None.	None.	5.00	9.81	1.2
	Hygienic Ice Co., Fifteenth and E streets NE.:										
251	Under shed	90	74	16	4.9	.032	.010	.0005	None.	....	1.45
252	Gr. I, well 2	138	114	24	5.9	.040	.010	.0005	.05	....	1.3
253	Gr. I, well 3	268	214	54	20.0	.040	.018	.0008	.10	....	1.2
254	Gr. II, well 1	204	182	22	20.0	.016	.018	.0008	.10	....	3.2
255	Gr. II, well 2	106	92	14	4.1	.022	None.	.0005	.10	....	1.1
256	Gr. II, well 3	90	84	6	2.8	.014	None.	.0008	.05	9.91	.8
257	Gr. II, well 4	144	110	34	3.3	.002	.010	.0006	.05	9.86	1.3
258	Spring	266	170	96	32.5	.002	.012	.0016	12.00	9.28	1.7
227	Spring	......	......	......	....	....	....	....	....	....	....
295	Corby Co., Langdon, D. C	182	166	16	5.3	.011	.020	None.	.08	....	.3
	Purity Ice Co., Fifth Street Market NW.:										
271	Well 1	384	226	158	70.0	.012	.006	.0090	.50	.19	1.4
272	Well 2	142	118	24	13.8	None.	None.	None.	None.	2.26	.8
273	Well 3	......	......	......	4.7	.008	.004	Tr.	.50	None.	1.5
	Auth Provision Co., Seventh street and Virginia avenue SW.:										
265	Well 1, 60 feet	228	160	68	32.3	.118	.002	.0017	None.	2.94	.9
266	Well 2, 39 feet	610	458	152	144.5	None.	None.	.0002	30.00	5.81	1.0
268	Chas. Javins & Sons, 930 C street NW	218	160	58	3.4	.084	None.	.0031	1.00	.3	1.3
267	Center Market, Seventh street NW	304	226	78	48.0	.246	.016	.0002	None.	....	1.9

Results of bacteriological and chemical examination of wells and springs used by the ice factories—Continued.

No. of sample.	Location.	Number of bacteria per cubic centimeter.	Fermentation in lactose bouillon.			B. coli present.			Remarks.
			0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.	
	Home Ice Co., Twelfth and V streets NW.:								
238	Drinking well	60	–	–	–	–	–	–	Bottled and sold.
239	Condensing well	162	–	+	+	....	+	......	For condensing.
240	Boiler room	9	–	–	–	–	–	–	For ice.
241	Under engine room.	14	–	–	–	–	–	–	Do.
	Hygienic Ice Co., Fifteenth and E streets NE.:								
251	Under shed	2	–	–	–	–	–	–	For condensing.
252	Gr. I, well 2	1	–	–	–	–	–	–	Do.
253	Gr. I, well 3	10	–	+	+	....	......	+	Do.
254	Gr. II, well 1	26	–	+	+	–	–	–	Do.
255	Gr. II, well 2	7	–	–	–	–	–	–	Do.
256	Gr. II, well 3	10	–	–	+	–	–	–	Do.
257	Gr. II, well 4	2	–	–	–	–	–	–	Do.
258	Spring	2	–	–	+	....	......	+	For ice.
227	Spring	310	–	–	+	....	......	+	Do.
295	Corby Co., Langdon NE	440	–	–	–	–	–	–	2 wells, mixed.
	Purity Ice Co., Fifth Street Market NW.:								
271	Well 1	18	–	–	+	–	–	–	For condensing only.
272	Well 2	1	–	–	–	–	–	–	Do.
273	Well 3	12	–	+	–	–	–	–	Do.
	Auth Provision Co., Seventh street and Virginia avenue SW.:								
265	Well 1, 60 feet	13	–	–	–	–	–	–	Not used for making ice.
266	Well 2, 39 feet	2	–	–	–	–	–	–	Do.
268	Chas. Javins & Sons, 930 C street NW	11	–	–	–	–	–	–	
267	Center Market, Seventh street NW	5	–	+	+	–	+	......	For condensing.

Bacteriological and chemical examination of ice.

No. of sample.	Dealer or manufacturer.	Sample obtained from—	Date.	Kind of ice.[a]
1	C. L. Balderson	Wagon	Aug. 1	Manufactured.
2	American Ice Co	....do	Aug. 2	Natural.
5	....do	....do	Aug. 7	Do.
8	....do	....do	Aug. 13	Do.
27	American Ice Co. (Georgetown)	Factory	Oct. 1	Plate.
3	W. E. Young	Wagon	Aug. 3	Manufactured.
4	John T. Smith	....do	Aug. 6	Natural.
6	S. Nally	....do	Aug. 7	Do.
7	W. H. Sanford	....do	Aug. 9	Manufactured.
9	M. M. Roper	....do	Aug. 14	Do.
10	W. A. Sharswood	....do	Aug. 15	Do.
11	——— Purcell	....do	Aug. 16	Do.
12	W. Greenfield	....do	Aug. 17	Do.
13	W. M. Weaver	....do	Aug. 21	Do.
14	A. C. Minns	....do	Aug. 27	Do.
15	H. H. Warner	....do	Aug. 29	Natural.
16	W. L. Bishop	....do	Aug. 31	Manufactured.
[b] 17	Chapin-Sacks	Factory	Sept. 25	Sheet.
[b] 18	Hygienic Ice Co	....do	....do	Plate.
[b] 19	....do	....do	....do	Can.
[b] 20	Purity Ice Co	....do	....do	Plate.
[b] 21	....do	....do	....do	Can.
[b] 22	Home Ice Co	....do	....do	Plate.
[b] 23	....do	....do	....do	Can.
24	Crystal Plate Co	....do	Oct. 1	Plate.
25	....do	....do	....do	Can.
26	Georgetown Ice Co	....do	....do	Plate.
28	Home Ice Co	....do	Oct. 2	Can.
29	....do	....do	....do	Plate.
30	Hygienic Ice Co	....do	....do	Do.
31	....do	....do	....do	Can.
32	Chapin-Sacks	....do	....do	Plate.
33	Purity Ice Co	....do	....do	Can.
34	....do	....do	....do	Plate.

[a] Kind of ice as stated by manufacturer, dealer, or driver of wagon.
[b] These samples were contaminated with zinc oxide by being collected in sterilized galvanized-iron buckets and hence no chemical analyses were made of them.

Bacteriological and chemical examination of ice—Continued.

No. of sample.	Dealer or manufacturer.	General characteristics.			
		Color.	Odor.	Turbidity.	Sediment.
1	C. L. Balderson	Slight yellow	None	None	Some trash.
2	American Ice Co	None	do	do	None.
5	do	do	do	do	Do.
8	do	do	do	do	Do.
27	American Ice Co. (Georgetown).	do	do	do	Very slight.
3	W. E. Young	do	do	do	Yellow-brown.
4	John T. Smith				
6	S. Nally	None	None	None	Very slight.
7	W. H. Sanford	do	do	do	Slight.
9	M. M. Roper	do	do	do	Slight trash.
10	W. A. Sharswood	Slight	do	Slight	None.
11	——— Purcell	do	do	do	Do.
12	W. Greenfield	None	Oily	None	Considerable.
13	W. M. Weaver	Very slight	None	do	Few fibrous particles.
14	A. C. Minns	do	do	do	Few fine black particles.
15	H. H. Warner	Slight	do	Very slight.	Few brown particles.
16	W. L. Bishop	do	Slight, putrid.	Slight	Slight black.
17	Chapin-Sacks				
18	Hygienic Ice Co				
19	do				
20	Purity Ice Co				
21	do				
22	Home Ice Co				
23	do				
24	Crystal Plate Co	None	Oily	None	Slight light-brown.
25	do	do	None	do	Very slight.
26	Georgetown Ice Co	do	do	do	Considerable light-brown.
28	Home Ice Co	do	do	do	Slight fibrous.
29	do	do	do	do	Considerable fine granular.
30	Hygienic Ice Co	do	do	do	Slight fibrous.
31	do	do	do	do	Very slight fibrous.
32	Chapin-Sacks	do	do	do	Do.
33	Purity Ice Co	do	do	do	Slight fibrous.
34	do	do	do	do	Very slight fibrous.

Bacteriological and chemical examination of ice—Continued.

No. of sample.	Dealer or manufacturer.	Total solids.			Chlorine.	Free ammonia.	Albuminoid ammonia.
		Total residue.	Mineral matter.	Volatile matter.			
1	C. L. Balderson	10	None.	10	1.4	0.442	None.
2	American Ice Co	None.	None.	None.	None.	.014	None.
5	.....do	20	12	8	.4	.018	0.010
8	.....do	12	12	None.	.5	.134	.074
27	American Ice Co. (Georgetown)	12	1	11	.5	.104	.046
3	W. E. Young	5	5	None.	.7	.115	None.
4	John T. Smith	8	7	1	.7	.020	.010
6	S. Nally	21	17	4	.7	.020	.090
7	W. H. Sanford	54	30	24	4.7	.538	.042
9	M. M. Roper	130	102	28	.8	.168	.044
10	W. A. Sharswood	32	10	22	2.1	.090	.018
11	Chas. H. Purcell	4	4	None.	1.3	.164	.054
12	W. Greenfield	226	80	146	55.5	.302	.044
13	W. M. Weaver	46	40	6	None.	.014	.090
14	A. C. Minns	38	20	18	2.3	.038	.016
15	H. H. Warner	68	52	16	.4	.016	.042
16	W. L. Bishop	116	80	36	3.5	.030	.024
17	Chapin-Sacks						
18	Hygienic Ice Co						
19	.....do						
20	Purity Ice Co						
21	.....do						
22	Home Ice Co						
23	.....do						
24	Crystal Plate Co	21	9	12	.7	.162	.042
25	.....do	12	None.	12	Tr.	.080	.018
26	Georgetown Ice Co	12	1	11	.3	.136	.046
28	Home Ice Co	13	2	11	1.0	.070	.056
29	.....do	21	7	14	.5	.064	.076
30	Hygienic Ice Co	17	9	8	1.0	.080	.040
31	.....do	26	12	14	1.9	.066	.016
32	Chapin-Sacks	19	12	7	.5	.436	.050
33	Purity Ice Co	8	None.	8	1.0	.118	.010
34	.....do	13	5	8	Tr.	.158	.020

Bacteriological and chemical examination of ice—Continued.

No. of sample.	Dealer or manufacturer.	Nitrites.	Nitrates.	Number of bacteria per cubic centimeter.	Fermentation in lactose bouillon.			B. coli found in.
					0.1 cc.	1 cc.	10 cc.	
								cc.
1	C. L. Balderson	0.0005	0.30	144	–	–	+	10
2	American Ice Co	None.	.10	192	–	+	–	1
5	....do	.0005	.08	(?)	–	–	+	10
8	....do	.0003	.50	28	–	–	+	10
27	American Ice Co. (Georgetown).	.0008	.03	650	–	–	–	–
3	W. E. Young	None.	Tr.	68	–	–	+	–
4	John T. Smith	None.	.08	47	–	–	–	–
6	S. Nally	.0005	.05	157	–	–	+	–
7	W. H. Sanford	None.	.10	161	–	+	+	1
9	M. M. Roper	.0015	.10	330	....	–	+	–
10	W. A. Sharswood	.0003	.50	(?)	–	–	+	10
11	Chas. H. Purcell	.0008	.20	(?)	–	–	–	–
12	W. Greenfield	.0143	13.5	17	–	–	–	–
13	W. M. Weaver	Tr.	Tr.	40	–	+	–	1
14	A. C. Minns	None.	.05	65	–	–	+	10
15	H. H. Warner	.0008	.10	168	–	+	+	–
16	W. L. Bishop	.0020	.65	72	–	–	–	–
17	Chapin-Sacks	....	....	112	+	–	–	–
18	Hygienic Ice Co	....	....	3	–	–	–	–
19	....do	....	....	50	–	–	+	–
20	Purity Ice Co	....	....	9	–	–	–	–
21	....do	....	....	8	–	–	–	–
22	Home Ice Co	....	....	65	–	–	+	–
23	....do	....	....	7	–	–	–	–
24	Crystal Plate Co	.0006	.03	455	–	–	–	–
25	....do	.0007	.04	20	–	–	–	–
26	Georgetown Ice Co	.0007	.04	230	–	–	+	10
28	Home Ice Co	.0014	.08	32	–	–	+	–
29	....do	.0005	.08	5,000	+	+	+	1
30	Hygienic Ice Co	.0025	.04	59	–	–	–	–
31	....do	.0010	.08	8	–	–	–	–
32	Chapin-Sacks	.0071	.05	470	–	–	+	–
33	Purity Ice Co	.0020	.04	4	–	–	–	–
34	....do	.0008	.05	8	–	+	–	1

The following chemical analyses by Doctor Lynch of ice manufactured in the District of Columbia were placed at our disposal by Dr. William C. Woodward:

No. of sample.	Dealer or manufacturer.	Date.	Kind of ice.[a]	Color.	Odor.	Condition.	Chlorine.
		1906.					
2	American Ice Co	Aug. 27	Can	Colorless	Odorless	Clear	4.00
3	do	do	Plate	do	do	do	4.00
4	Chapin & Saks Co	do	do	do	do	do	2.00
5	Home Ice Co	do	Can	do	do	do	4.00
6	C. C. Balderson	Aug. 28	Not stated	do	do	do	7.00
7	American Ice Co	do	Natural	do	do	do	2.00
8	Chr. Heurich	do	Can	do	do	do	5.00
9	do	do	Plate	do	do	do	3.00
10	Nicholas Auth Co	Aug. 29	Can	do	do	do	2.00
11	Georgetown Ice Co	do	Plate	do	do	do	2.00
12	Crystal Plate Ice Co	do	Can	do	do	do	2.00
13	American Ice Co	do	Plate	do	do	do	2.00
14	H. Loeffler	do	Can	do	do	do	4.00
15	Purity Ice Co	do	do	do	do	do	3.00
16	do	do	Plate	do	do	do	3.00

No. of sample.	Dealer or manufacturer.	Nitrogen as— Ammonia. Free.	Nitrogen as— Ammonia. Albuminoid.	Nitrogen as— Nitrites.	Nitrogen as— Nitrates.	Oxygen required to oxidize organic matter.
2	American Ice Co	0.12	0.04	0.00	Trace	0.88
3	do	.32	.12	.00	do	1.32
4	Chapin & Saks Co	.24	.07	.00	do	.96
5	Home Ice Co	.16	.07	.00	do	.96
6	C. C. Balderson	.15	.12	.00	do	.80
7	American Ice Co	.08	.05	.00	do	.88
8	Chr. Heurich	.08	.01	.00	do	1.00
9	do	.04	.01	.00	do	1.20
10	Nicholas Auth Co	.18	.03	.00	do	.72
11	Georgetown Ice Co	.19	.03	.00	do	.48
12	Crystal Plate Ice Co	.16	.03	.00	do	.32
13	American Ice Co	.20	.04	.00	do	1.08
14	H. Loeffler	.25	.06	.00	do	1.04
15	Purity Ice Co	.30	.01	.00	do	.64
16	do	.16	.05	.00	do	.40

[a] According to Doctor Lynch the analyses of these samples of ice do not show the presence of any injurious contamination.

Some interesting conclusions may be drawn from a comparison between the chemical and bacteriological examination of the ice samples and the water used for manufacturing the ice.

The ice samples Nos. 24, 26, 27, 29, 32, and 34 were frozen by the plate system from tap (river) water. Such ice, however, contained conspicuously less total solids, less chlorine, and less nitrates than are found in tap water. This may be explained by an extrusion of

these substances known to take place during freezing; the process of freezing, like any process of crystallization, being one of purification.

On the other hand, in these same specimens of ice the free ammonia is high. This may be accounted for by the fact that there is always some leakage of this gas about ice factories using the ammonia process, and, as is well known, ammonia sometimes occurs in manufactured ice in such quantities as to impart a distinctly alkaline taste.

The albuminoid ammonia and nitrites show but little if any change.

It is further interesting to note that, while the chemical analysis of the water used in the plate ice system indicates an improvement in its quality as compared with tap water, the bacterial examination shows the contrary.

The six specimens of plate ice, for example, contained the following comparatively high bacterial contaminations, whereas tap water from which it is made averaged only 64 organisms per cubic centimeter during the same period of time:

No. of sample.	Manufacturer.	Organisms per cubic centimeter.	Colon bacillus.
24	Crystal Plate Co	455	Absent.
29	....do	5,000	In 1 cc.
26	Georgetown Ice Co	230	In 10 cc.
27	....do	650	Absent.
32	Chapin-Sacks	470	Do.
34	Purity Ice Co	8	In 1 cc.

This discrepancy between the bacteriological and chemical findings doubtless signifies that the water in the tanks is contaminated by the unclean methods already noted in the inspection of the factories, and that, while the organisms are not entirely destroyed at the low temperature of the ice tank, they can not effect those changes in water which they bring about at ordinary temperatures and which result in the production of characteristic substances whose presence can be recognized and determined by chemical methods.

Specimen No. 29 is a striking example of this condition. This ice contains 5,000 bacteria per cubic centimeter with the colon bacillus present in at least each cubic centimeter. On the other hand, the chemical analysis of this specimen does not indicate injurious pollution. It would seem reasonable to conclude, therefore, that the bacterial contamination had probably dropped into the water from the soiled shoes of the men working on the ice or from other sources just before freezing.

The fact that all sorts of foreign particles, such as "trash," fibrous and granular débris, straw. etc., were found imbedded in and on the

ice is another indication of lack of care and cleanliness in manufacture and storage.

In this connection attention is also called to the spring No. 257 and 258 used for making ice. Evidences of pollution are found in this spring and its location is such as to render it liable to serious contamination. It therefore should not be used for the manufacture of ice.

IV.—WATERS OF PUBLIC WELLS AND SPRINGS AND THEIR RELATION TO TYPHOID FEVER.

WATERS OF PUBLIC WELLS AND SPRINGS AND THEIR RELATION TO TYPHOID FEVER.

The waters of shallow wells have been regarded by many observers as a means of conveying the infection of typhoid fever. There are many shallow wells in the District of Columbia used by the public. Therefore we made a particular study of this subject.

Each well was visited and its condition, as well as the surroundings, noted so far as they had any bearing upon the problem. As it is generally recognized that one of the chief sources of infection of well water is from the surface, the condition of the well and the possibilities of such contamination are recorded in each instance.

It is also possible for wells to become polluted from broken sewers and from seepage from near by privies. Therefore the relation of each well to the nearest sewer and the number of privies in the neighborhood are stated.

Other data which obviously have an important bearing on this subject, such as the depth of water in the well, have been collected and conveniently arranged for comparison and study.

In our epidemiological studies we conducted special inquiries into the use of well water by the patient during the thirty days prior to onset of illness. This information has been so arranged that it may be seen at a glance just how many of the cases that occurred during the summer in the District of Columbia drank the water of any particular well.

Samples of water from every well in the District were submitted to the usual chemical and bacteriological examination. The results of these laboratory studies have been arranged and correlated with the other data. Finally, a spot map (No. 8) of all the cases occurring in the District was made, including the locations of all the public wells, in order to see whether there was any geographic grouping of the cases about any particular well or spring. As a result of these studies, the details of which are given in the following pages, we may say that no relation between the drinking of well water and the occurrence of typhoid fever could be demonstrated. We are of the opinion, however, that the use of the water of the shallow wells of this locality for drinking purposes may be a menace to the health of the community, and in this opinion we are sustained, not only by our own observations, but also by the conclusions of all who have ever had occasion to investigate this subject.

THE DEEP WELLS.

By "deep" wells is meant the so-called drilled or "artesian" wells. Such wells in the District are rarely less than 100 feet below the mean surface level and consist of an iron pipe or tube 6 or 8 inches in diameter. There are 23 such deep wells used by the public in the District of Columbia. Several others, used for institutional, manufacturing, or private purposes, were not included in our studies. For the most part, the water from these deep wells is of excellent quality, chemically and bacteriologically. Some of them are practically sterile, and fermenting organisms are not in evidence. In other words, these deep well waters, from a bacteriological standpoint, show the absence of surface contamination or sewage pollution.

The chemical analyses also go to show that these wells furnish water of unquestioned purity. In only three instances was the free ammonia found to be somewhat higher than the accepted standards.

SUMMARY—DEEP WELLS.

Number.—In the following summary the "number" is the laboratory designation of the well and corresponds for ready reference with the same number in the bacteriological and chemical tables.

Location.—The list of wells in the District was furnished us by the health officer. Each well was visited and the location verified.

Kind.—This refers to the kind of pump, whether wooden or iron.

Condition.—This refers to the condition of the pump. The base and platform in reference to surface contamination are specifically noted. Note is also made in each instance as to whether the waste water runs off by surface drainage or runs to the sewer.

Depth.—Under "Depth" the first figure is the distance of the bottom of the tube to the mean surface level; the second is the height to which the water stands in the well, referring to the bottom as zero. This data was obtained from the water department of the District of Columbia.

Sewer.—Under "Sewer" the figure "depth" is the distance of the center line of the sewer pipe below the mean surface grade; the figure "distance from well" is the horizontal distance from the center line of the sewer to the approximate center of the well. The depth of the sewers was obtained from the sewer department of the District of Columbia. The distance of sewers from wells are scaled from drawings, and are only roughly approximated. Many of the wells seem to be located directly on the line of the sewers.

Privies.—There are about 3,600 privies registered at the health office; schools equipped with the "Smead system" being rated as a single privy.

In the following summary the information regarding the relation of privies to the various wells was obtained from the spot map prepared by the health department of the District of Columbia through the courtesy of Dr. Wm. C. Woodward, health officer.

Bacteriologically.—Well waters containing less than 100 bacteria per cubic centimeter and no fermenting organisms are classed as good; those containing more than 100 bacteria per cubic centimeter and no fermenting organisms are classed as fair; those containing fermenting organisms but no colon bacilli are classed as indicating surface contamination; and those containing the colon bacillus are classed as indicating sewage pollution. For bacteriological methods see page 261.

Chemically.—Well waters high in chlorin and nitrates are regarded as indicating remote pollution and those high in free and albuminoid ammonia and nitrites are classified as polluted.

Epidemiologically.—The number of cases of typhoid among persons using the water of each particular well refers to the cases occurring in the District and reported between June 1 and November 1, 1906.

DEEP WELLS—NORTHWEST SECTION.

No. 3.

Location.—First and G streets NW., Gales School (New Jersey and Massachusetts avenues).

Kind.—Iron.

Condition.—Fair; old; pipe drain to sewer.

Depth.—Deep; below surface, 141 feet; water, 137 feet.

Sewer.—Depth, 10 feet; distance from well, 20 feet.

Privies.—Nearest, two blocks.

Bacteriologically.—Good.

Chemically.—Unpolluted.

The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
177	May 26	Frequently	?.
251	July 4	Occasionally	Contact.

No. 17.

Location.—Twelfth and M streets NW. (southwest corner).

Kind.—Iron.

Condition.—Out of order.

Depth.—Below surface, 149 feet; water, 38 feet; deep.

Sewer.—Depth, 10 feet; distance from well, 8 feet(?).

Bacteriologically.—Good.

Chemically.—Unpolluted.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
464	July 25	Frequently	?.

No. 18.

Location.—Seventh and M streets NW. (southeast corner).

Kind.—Iron.

Condition.—Old; pipe drain to sewer.

Depth.—Deep; below surface, 151 feet; water, 54 feet.

Sewer.—Depth, 7 feet; distance from well, 15 feet.

Privies.—One within one and one-half blocks.

Bacteriologically.—Good.

Chemically.—Unpolluted.

The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
636	Aug. 12	Occasionally	?.
911	Sept. 25	Frequently	?.

No. 21.

Location.—O street, between Sixth and Seventh NW. (north side, mid-block).

Kind.—Iron.

Condition.—Old; badly rotten, middle third; pipe drain to sewer.

Depth.—Deep; below surface, 201 feet; water, 35 feet.

Sewer.—Depth, 10 feet; distance from well, 60 feet.

Privies.—Nearest, one and one-half blocks.

Bacteriologically.—Good.

Chemically.—Unpolluted.

No. 71.

Location.—Pennsylvania avenue and I street, between Twentieth and Twenty-first streets NW. (south side).

Kind.—Iron.

Condition.—Old; rotten; split; pipe drain to sewer.

Depth.—Deep; below surface, 203½ feet; water, 35 feet.

Sewer.—Depth, 8 feet; distance from well, 100 feet.

Privies.—Nearest, one and one-half blocks.

Bacteriologically.—Presence of an occasional colon bacillus, probably indicating contamination from the surface. Pump should be repaired.

Chemically.—Unpolluted.

The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
471	July 30	Occasionally	Contact.
697	Aug. 4	Frequently	?.

No. 105.

Location.—Sixth and B streets NW. (northwest corner).
Kind.—Iron.
Condition.—Fair; pipe drain to sewer.
Depth.—Deep; below surface, 140 feet; water, 130 feet.
Sewer.—Depth, 5 feet; distance from well, 30 feet.
Privies.—None within several blocks.
Bacteriologically.—Good.
Chemically.—Unpolluted.

No. 167.

Location.—Brightwood avenue NW. (east side, opposite Brightwood Hotel).
Kind.—Iron.
Condition.—Cracked, middle third; surface drainage.
Depth.—Deep; below surface, 98 feet 10½ inches; water, —?.
Sewer.—Depth, 11 feet; distance from well, 50 feet.
Bacteriologically.—Good.
Chemically.—Unpolluted.

No. 168.

Location.—Eighth street, between Varnum and Upshur streets NW. (east side).
Kind.—Iron.
Condition.—Cracked, bricks loose at base; pipe drainage to sewer.
Depth.—Deep; below surface, 195½ feet; water, 35 feet.
Sewer.—Depth, 8 feet; distance from well, 20 feet.
Privies.—None within two blocks.
Bacteriologically.—Good.
Chemically.—Unpolluted.

Location.—Third and H streets NW. (southwest corner).
Condition.—Not in use since last summer.
Depth.—Deep; below surface, 166½ feet; water, 123 feet.
Sewer.—Depth, 10 feet; distance from well, 5 feet.
Privies.—None in block; none within three blocks.

Location.—N, between Fourth and Fifth NW. (north side, mid-block).
Kind.—Iron.
Condition.—Broken; not in use for a year.
Depth.—Deep; below surface, 150 feet; water, 55 feet.
Sewer.—Depth, 12 feet; distance from well, 12 feet.
Privies.—One in block.

DEEP WELLS—NORTHEAST SECTION.

No. 36.

Location.—Third and H streets NE. (northeast corner).
Kind.—Iron.
Condition.—Rotten in lower third; pipe drain to sewer; out of order.
Depth.—Deep; below surface, 157 feet; water, 103 feet.
Sewer.—Depth, 9 feet; distance from well, 10 feet.
Privies.—None in block; two within two blocks.
Bacteriologically.—Good; practically sterile.
Chemically.—Unpolluted.

No. 133.

Location.— Eleventh street NE. (opposite East Capitol, east side).
Kind.— Iron.
Condition.— Old; rotten at base; pipe drain to sewer.
Depth.— Deep; below surface, 191 feet; water, 70 feet.
Sewer.— Depth, 10 feet; distance from well, 75 feet.
Privies.— None within three blocks.
Bacteriologically.— Good.
Chemically.— Unpolluted.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
956	Oct. 11	Occasionally	?

No. 134.

Location.— Twelfth and K streets NE. (northwest corner).
Kind.— Iron.
Condition.— Fair; pipe drain to sewer.
Depth.— Deep; below surface, 188 feet; water, 153 feet.
Sewer.— Depth, 25 feet; distance from well, 50 feet.
Privies.— Four within two blocks.
Bacteriologically.— Good.
Chemically.— Unpolluted.

No. 136.

Location.— Seventh street and Maryland avenue NE.
Kind.— Iron.
Condition.— Old; cracked; pipe drain to sewer.
Depth.— Deep; below surface, 232 feet; water, 158 feet.
Sewer.— Depth, 16 feet; distance from well, 5 feet.
Privies.— None within three blocks.
Bacteriologically.— Good; practically sterile.
Chemically.— Unpolluted.

No. 140.

Location.— B and Warren streets NE. (northwest corner).
Kind.— Iron.
Condition.— Bricks loose at base; cracked middle third; pipe drain to sewer.
Depth.— Deep; below surface, 125 feet; water, 70 feet.
Sewer.— Depth, 6 feet; distance from well, 5 feet.
Privies.— Twelve within radius of one block. None in same block. (?)
Bacteriologically.— Good.
Chemically.— Unpolluted.

No. 141.

Location.— Fifteenth street and Maryland avenue NE. (northwest corner).
Kind.— Iron.
Condition.— Fair; pipe drain to sewer.
Depth.— Deep; below surface, 197 feet; water, 166 feet.
Sewer.— Depth, 10 feet; distance from well, 5 feet.

Privies.— Two within two blocks.
Bacteriologically.— Good.
Chemically.— Unpolluted.

No. 143.

Location.— Woodward and Fairview avenues NE. (Fairview, D. C.).
Kind.— Iron.
Condition.— Fair; surface drainage; water stands in stagnant pools about well; bricks loose at base.
Depth.— Deep; below surface, 175 feet; water, 45 feet.
Sewer.— None in neighborhood.
Privies.— Six within two blocks.
Bacteriologically.— Good.
Chemically.— Unpolluted.

DEEP WELLS—SOUTHWEST SECTION.

No. 53.

Location.— Seventh and H streets SW. (southeast corner).
Kind.— Iron.
Condition.— Cracked middle third; pipe drain to sewer.
Depth.— Deep; below surface, 144 feet; water, 109 feet.
Sewer.— Depth, 12 feet; distance from well, 5 feet.
Bacteriologically.— Good; practically sterile.
Chemically.— Unpolluted.

The following two cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
353	July 12	Occasionally	?
383	June 13	do	?

No. 107.

Location.—Sixth and G streets SW. (southeast corner).
Kind.—Iron.
Condition.—Fair; pipe drain to sewer.
Depth.—Deep; below surface, 145 feet; water, (?).
Sewer.—Depth, 10 feet; distance from well, 35 feet.
Privies.—Three in block; 2 within one and one-half blocks.
Bacteriologically.—Good.
Chemically.—Unpolluted.

No. 108.

Location.—Half and T streets SW. (northeast corner).
Kind.—Iron.
Condition.—Good; pipe drain to underground drain.
Depth.—Deep; below surface, 207½ feet; water, 180½ feet.
Sewer.—None within four blocks.
Privies.—Four in same block; 3 more within two blocks.
Bacteriologically.—Good.
Chemically.—Unpolluted.

No. 110.

Location.—Third and D streets SW. (northwest corner).
Kind.—Iron.
Condition.—Fair; pipe drain to sewer.
Depth.—Deep; below surface, 96 feet; water, 81 feet.
Sewer.—Depth, 11 feet; distance from well, 12 feet.
Privies.—Seven in block; 5 within two blocks.
Bacteriologically.—Good.
Chemically.—Unpolluted.

No. 186.

Location.—Second street and Virginia avenue SW. (northwest corner).
Kind.—Iron.
Condition.—Fair; pipe drain to sewer; very dirty surroundings, due to building railroad along Virginia avenue.
Depth.—Deep; below surface, 146 feet; water, 131 feet.
Sewer.—Depth, 8 feet; distance from well, 20 feet.
Privies.—One in block; 12 in surrounding blocks.
Bacteriologically.—Good.
Chemically.—Unpolluted.
The following 3 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
203	June 23	Occasionally	?.
253	July 1	....do	?.
677	Aug. 22	Habitually	?.

DEEP WELLS—SOUTHEAST SECTION.

No. 138.

Location.—Eighth and I streets SE. (northeast corner).
Kind.—Iron.
Condition.—Old; rotten; pipe drain to sewer.
Depth.—Deep; below surface, 97 feet; water, 32 feet.
Sewer.—Depth, 9 feet; distance from well, 50 feet.
Privies.—One in opposite block.
Bacteriologically.—Good; practically sterile.
Chemically.—Unpolluted.
The following 3 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
445	July 28	Occasionally	?.
468	Aug. 3	....do	?.
959	Oct. 5	Frequently	?.

Location.—Tenth street and South Carolina avenue SE. (southeast corner).
Kind.—Wood.
Condition.—Out of order.

Depth.—Deep; below surface, 147 feet; water, 68 feet.
Sewer.—Depth, 9 feet; distance from well, 15 feet.
Privies.—One in block; 1 other within three blocks.

Location.—Third and M streets SE. (northwest corner).
Condition.—Out of order.
Depth.—Deep; below surface, 223 feet; water, 188 feet.
Sewer.—Depth, 10 feet; distance from well, 6 feet.
Privies.—Four in block; 6 within radius of one block.

Location.—Second street and North Carolina avenue SE. (northeast corner).
Condition.—Out of order.
Depth.—Deep; below surface, 233½ feet; water, 172 feet.
Sewer.—Depth, 12 feet; distance from well, 20 feet.
Privies.—One in opposite block.

Location.—Fourteenth and C streets SE.
Condition.—Out of order.
Depth.—Deep; below surface, 149 feet; water 83 feet.
Sewer.—Depth, 12 feet; distance from well, 15 feet.
Privies.—Eighteen within radius of one block.

No. 182.

Location.—Stanton avenue near T street SE. (Hillsdale, D. C.).
Kind.—Iron.
Condition.—Fair; set on brick base; surface drainage; residents say water is "no good" and do not use it.
Depth.—Deep; below surface, 130 feet; water, (?).
Sewer.—None in neighborhood.
Privies.—None within three blocks.
Bacteriologically.—Good; practically sterile.
Chemically.—Unpolluted.

No. 184.

Location.—Stanton and Elvan avenues SE. (Hillsdale, D. C.).
Kind.—Special iron pump.
Condition.—Works with difficulty; water little used.
Depth.—Deep; below surface, 185½ feet; water, (?).
Sewer.—None in neighborhood.
Privies.—Two within three blocks.
Bacteriologically.—Good; practically sterile.
Chemically.—Unpolluted.

BACTERIOLOGY OF THE DEEP WELLS IN THE DISTRICT OF COLUMBIA.

In the following table are given the results of the bacteriological examinations of the water of the deep wells. The number in the first column refers to our laboratory number. The analyses marked "L" were made by Mr. F. F. Longley, chief chemist of the filtration plant.

Mr. Longley's results were furnished through the kindness of the officers in charge of the Washington filtration plant and are included in this table for purposes of completeness and comparison.

No.	Location.	Date.	Number of bacteria per cubic centimeters.	Ferment in lac-bouillon.			B. coli present.		
				0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.
	Northeast.	1906.							
36	Third and H streets	July 24	1	—	—	—	—	—	—
411	.....do	Oct. 10	2	......	—	—	—	—	—
L	.....do	July 10	2	......	......	......	—	—	—
133	Eleventh and East Capitol streets	Aug. 15	75	—	—	—	—	—	—
446	.....do	Oct. 13	5	......	—	—	—	—	—
L	.....do	July 10	2	......	......	......	—	—	—
134	Twelfth and K streets	Aug. 15	7	—	—	—	—	—	—
403	.....do	Oct. 9	2	......	—	—	—	—	—
L	.....do	July 21	130	......	......	......	—	—	—
136	Seventh street and Maryland avenue	Aug. 15	2	—	—	—	—	—	—
414	.....do	Oct. 10	1	......	—	—	—	—	—
L	.....do	July 10	3	......	......	......	—	—	—
140	B and Warren streets	Aug. 16	160	—	—	—	—	—	—
445	.....do	Oct. 13	1	......	—	—	—	—	—
L	.....do	July 21	47	......	......	......	—	—	—
141	Fifteenth street and Maryland avenue	Aug. 16	4	—	—	—	—	—	—
332	.....do	Sept. 26	2	—	—	—	—	—	—
402	.....do	Oct. 9	1	......	—	—	—	—	—
L	.....do	July 21	225	......	......	......	—	—	—
143	Fairview avenue	Aug. 16	7	—	—	—	—	—	—
404	.....do	Oct. 9	5	......	—	—	—	—	—
L	.....do	July 21	26	......	......	......	—	—	—
	Southeast.								
138	Eighth and I streets	Aug. 15	1	—	—	—	—	—	—
443	.....do	Oct. 13	1	......	—	—	—	—	—
L	.....do	July 10	4	......	......	......	—	—	—
182	Stanton avenue	Aug. 24	0	—	—	—	—	—	—
388	.....do	Oct. 8	1	—	—	—	—	—	—
184	Stanton and Elvan avenues	Aug. 24	4	—	—	—	—	—	—
	Northwest.								
3	New Jersey and Massachusetts avenues	July 16	3	—	—	—	—	—	—
448	.....do	Oct. 15	21	......	—	......	—	—	—
L	.....do	July 18	15	......	......	......	—	—	—
17	Twelfth and M streets	July 19	7	—	—	—	—	—	—
449	.....do	Oct. 15	4	......	—	......	—	—	—
L	.....do	July 18	30	......	......	......	—	—	—
18	Seventh and M streets	July 19	7	—	—	—	—	—	—
450	.....do	Oct. 15	3	......	—	......	—	—	—
L	.....do	July 18	10	......	......	......	—	—	—
21	O street, between Sixth and Seventh	July 19	5	—	—	—	—	—	—
451	.....do	Oct. 15	1	......	—	......	—	—	—
L	.....do	July 18	10	......	......	......	—	—	—
71	Pennsylvania avenue and I street	July 31	17	—	—	—	—	—	—
452	.....do	Oct. 15	8	—	—	......	—	—	—
L	.....do	July 18	40	......	......	......	—	—	+
105	Sixth and B streets	Aug. 8	31	—	—	+	—	—	—
431	.....do	Oct. 12	47	—	—	+	—	—	—
L	.....do	July 21	220	......	......	......	—	—	—
167	Brightwood Hotel	Aug. 22	20	—	—	—	—	—	—
439	.....do	Oct. 13	1	......	—	—	—	—	—

No.	Location.	Date.	Number of bacteria per cubic centimeters.	Ferment in lac-bouillon. 0.1 cc.	Ferment in lac-bouillon. 1 cc.	Ferment in lac-bouillon. 10 cc.	B. coli present. 0.1 cc.	B. coli present. 1 cc.	B. coli present. 10 cc.
	Northwest—Continued.	1906.							
168	Eighth, between Varnum and Upshur.	Aug. 22	18	—	—	—	—	—	—
440	.....do	Oct. 13	2	......	—	—	—	—	—
	Southwest.								
53	Seventh and H streets	July 26	1	—	—	—	—	—	—
430	.....do	Oct. 12	0	......	—	—	—	—	—
L	.....do	July 21	30	......	......	......	—	—	—
107	Sixth and G streets	Aug. 9	15	—	—	—	—	—	—
432	.....do	Oct. 2	5	......	—	—	—	—	—
L	.....do	July 21	61	......	......	......	—	—	—
108	Half and T streets	Aug. 9	6	—	—	—	—	—	—
460	.....do	Oct. 16	5	......	—	—	—	—	—
L	.....do	July 21	79	......	......	......	—	—	—
110	Third and D streets	Aug. 9	0	—	—	—	—	—	—
333	.....do	Sept. 26	2	—	—	—	—	—	—
433	.....do	Oct. 12	1	......	—	—	—	—	—
L	.....do	July 21	285	......	......	......	—	—	—
186	Second street and Virginia avenue	Aug. 24	9	—	—	—	—	—	—
434	.....do	Oct. 12	0	......	—	—	—	—	—
L	.....do	July 21	57	......	......	......	—	—	—

For details of chemical analyses of these well waters, see section XII, page 320.

THE SHALLOW WELLS.

By "shallow" wells is understood those which are dug and lined with stone or brick work. The cylinder is usually 5 or 6 feet in diameter and rarely over 30 feet deep. We have studied water from 63 such shallow wells used in the District for public water supply.

Thirty-one of the 63 shallow wells gave indications of sewage pollution upon both bacteriological and chemical analyses. We unhesitatingly recommend that these 31 wells be closed at once. They are as follows:

No.	Location.	No.	Location.
	Northeast.		*Northwest*—Continued.
24	Fourth and E streets.	15	Massachusetts avenue between Sixth and Seventh streets.
38	E street between Eighth and Ninth.	46	In front of 1522 Wisconsin avenue.
135	Eleventh and F streets.	48	Twenty-eighth and O streets.
217	Benning cross roads.	77	Sixteenth and Corcoran streets.
218	Benning School.	111	New Jersey avenue and Pierce street.
225	South Dakota avenue and Vista street.	128	Eighth street and Barry place.
	Northwest.	131	New Jersey and Morgan avenues.
8	Tenth and N streets.	169	Newton street east of Brightwood avenue.
9	Tenth and K streets.	175	Thirty-third street and Wisconsin avenue.
13	Third and Indiana avenue.	202	Zoological Park pump.

No.	Location.	No.	Location.
	Southwest.		*Southeast*—Continued.
104	South Capitol and M streets, Ford's brick yard.	116	Jefferson street between Monroe and Fillmore streets.
	Southeast.	139	L street between Thirteenth and Fourteenth streets.
30	Fourth street and South Carolina avenue.	145	Eleventh street and South Carolina avenue.
32	Fifth and G streets.	183	Hamilton road.
35	Third and C streets.	209	Twentieth and Joliet streets.
91	Seventeenth and Harrison streets, Anacostia.	422	Ninth and E streets.
101	Third street and Pennsylvania avenue.		

Of the remaining wells, 29 must be regarded as suspicious, judging from the results of the bacteriological and chemical analyses. For the most part the water of these 29 wells is fairly good from a bacteriological standpoint; but the high chlorin and nitrate content clearly indicate remote pollution and the danger of recent pollution must ever be present. We recommend that these wells also be closed. If, however, it is decided to continue using the waters from these wells, facilities should be afforded the health officer to watch them closely by frequent chemical and bacteriological analyses. The list is as follows:

No.	Location.	No.	Location.
	Northeast.		*Northwest*—Continued.
23	Third and D streets.	170	Sixth street north of Fairmont street.
26	Second and G streets.	204	Massachusetts avenue near Wisconsin avenue.
28	Sixth and C streets.	226	Brightwood avenue, in front of Jones's blacksmith shop.
40	Eighth and A streets.	235	Hurst and Elliott streets.
109	North Capitol between B and C streets.		
129	Keating street between Lincoln avenue and First street.		*Southeast.*
	Northwest.		
5	Sixth street between F and G streets.	34	Fourth street and Seward square.
6	Ninth and H streets.	92	Seventh and B streets.
11	Seventeenth and K streets.	102	Seventh street between B and C streets.
14	New York avenue between Fourth and Fifth streets.	103	Eighth and D streets SE.
44	Wisconsin avenue and Q street.	117	Fillmore and Jackson streets.
45	In front of 1614 Thirty-second street.	146	I street between Eleventh and Twelfth streets.
57	Thirty-fourth street and Valta place.	185	Stanton and Pomeroy streets.
58	Thirty-fourth street and Wisconsin avenue.	208	Stanton School.
67	Thirty-fifth and Reservoir streets.	385	T Street hill.
72	Third and L streets.		

Only 3 of the 63 shallow wells in the District show no laboratory indication of injurious pollution. They are as follows:

No.	Location.
	Northeast.
224	Old Philadelphia, between Twelfth and Thirteenth streets.
	Northwest.
127	Twelfth street and Florida avenue.
130	North Capitol and Randolph streets.

It will be noticed, however, that only a few examinations were made of these 3 wells and it is reasonable to assume that if frequent analyses were conducted, indications of pollution would sooner or later be found in them. Further, it will be seen that the waters of many of these shallow wells show considerable variation in chemical composition, and in the number and character of bacteria. This, in itself, is an index of danger from a sanitary standpoint, indicating intermittent sources of sewage or surface pollution.

It is also evident from a study of our summaries that there appears to be a relationship between the proximity and number of privies to the wells, and the bacteriological and chemical findings; also, that most of the wells with broken pumps and leaky platforms, permitting surface contamination, give evidence of this condition in the laboratory analyses. From the fact that 31 of the 63 wells show indications of sewage pollution and 29 of the others are suspicious, we feel justified in recommending the closing of all the shallow wells in the District of Columbia.

It is evident that a densely inhabited area, with miles of sewers—some of them doubtless broken or leaky, and with almost 4,000 privies—must produce a more or less sewage-polluted condition of the soil favorable for the contamination of shallow wells. Shallow wells and privies, on general principles, have been gradually eliminated from all large cities having an abundant water supply and sewerage system. We unhesitatingly subscribe to this view, and believe that, upon general principles alone, the shallow wells in Washington should be condemned, a conviction that is amply confirmed by our chemical and bacteriological analyses.

SUMMARY—Shallow wells.

For an explanation of the data in the following summaries, see page 116.

SHALLOW WELLS—NORTHWEST SECTION.

No. 5.

Location.—Sixth street, between F and G streets NW. (east side, mid-block).
Kind.—Wood.
Condition.—Old; bricks loose at base; pipe drain to sewer.
Depth.—Below surface, 28 feet; water, 3 feet.
Sewer.—Depth, 9 feet; distance from well, 20 feet.
Privies.—Nearest, two blocks.
Bacteriologically.—Good.
Chemically.—Remote pollution.
The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
246	July 5	Occasionally	?.
458	July 20	do	?.

No. 6.

Location.—Ninth and H streets NW. (southeast corner).
Kind.—Wood.
Condition.—Old; pipe drain to sewer.
Depth.—Below surface, 26 feet; water, 4 feet.
Sewer.—Depth, 10 feet; distance from well, 20 feet.
Privies.—None within two blocks.
Bacteriologically.—Good.
Chemically.—Remote pollution.
The following 4 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
174	May 27	Occasionally	?.
221	June 27	Frequently	?.
344	July 14	do	?.
438	July 27	Occasionally	?.

No. 8.

Location.—Tenth and N streets NW. (northeast corner).
Kind.—Wood.
Condition.—Rotten at base; old; cracked; pipe drain to sewer.
Depth.—Below surface, 37 feet; water, 22 feet.
Sewer.—Depth, 11 feet; distance from well, 0 feet.
Privies.—Two in block.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Polluted.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
231	July 2	Occasionally	?.

No. 9.

Location.—Tenth and K streets NW. (northwest corner).
Kind.—Wood.
Condition.—Old; bricks loose at base; pipe drain to sewer.
Depth.—Below surface, 10 feet; water, 2 feet.
Sewer.—Depth, 11 feet; distance from well, 30 feet.
Privies.—Nearest, two and one-half blocks.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.
The following 5 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
470	July 30	Frequently	?.
488	July 25	.....do	?.
665	Aug. 25	Occasionally	?.
800	Sept. 8	.....do	?.
844	Sept. 15	.....do	Contact.

No. 11.

Location.—Seventeenth and K streets NW. (northeast corner).
Kind.—Wood.
Condition.—Fair; pipe drain to sewer; bricks loose at base.
Depth.—Below surface, 24 feet; water, 4 feet.
Sewer.—Depth, 9 feet; distance from well, 10 feet.
Privies.—One in opposite block.
Bacteriologically.—Fair.
Chemically.—Remote pollution.
The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
267	July 2	Occasionally	?.
844	Sept. 15	.....do	Contact.

No. 13.

Location.—Third street and Indiana avenue NW. (northeast corner).
Kind.—Wood.
Condition.—Fair; pipe drain to sewer.
Depth.—Below surface, 7 feet 6 inches; water, 2 feet.
Sewer.—Depth, 14 feet; distance from well, 40 feet.
Privies.—None within three blocks.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Polluted.

The following 3 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
364	July 21	Frequently	?.
546	Aug. 1	....do	?.
988	Oct. 15	....do	?.

No. 14.

Location.—New York avenue, between Fourth and Fifth streets NW. (south side, middle).

Kind.—Wood.

Condition.—Old; bricks loose at base; pipe drain to sewer.

Depth.—Below surface, 14 feet; water, 4 feet.

Sewer.—Depth, 10 feet; distance from well, 10 feet.

Privies.—None in block; 6 within two blocks.

Bacteriologically.—Fair.

Chemically.—Remote pollution.

The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
465	July 24	Frequently	?.
484	Aug. 1	Occasionally	?.

No. 15.

Location.—Massachusetts avenue, between Sixth and Seventh streets NW. (in front of No. 619).

Kind.—Wood.

Condition.—Old; pipe drain to sewer.

Depth.—Below surface, 31 feet; water, 17 feet.

Sewer.—Depth, 9 feet; distance from well, 10 feet.

Privies.—None in block; 3 within radius of two blocks.

Bacteriologically.—Indicates sewage pollution; variable.

Chemically.—Remote pollution.

No. 44.

Location.—Wisconsin avenue and Q street NW. (southwest corner).

Kind.—Wood.

Condition.—Old; pipe drain to sewer.

Depth.—Below surface, 29 feet 2 inches; water, 4 feet.

Sewer.—Depth, ?; distance from well, 0 feet.

Privies.—None in block; 2 within two blocks.

Bacteriologically.—Good.

Chemically.—Remote pollution.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
607	Aug. 11	Occasionally	Milk.

No. 45.

Location.—In front of No. 1614 Thirty-second street NW.
Kind.—Wood.
Condition.—Old; bricks loose at base; surface drainage to sewer.
Depth.—Below surface, 20 feet; water, 3 feet.
Sewer.—Depth, 8½ feet; distance from well, 20 feet.
Privies.—None in block.
Bacteriologically.—Fair.
Chemically.—Remote pollution.
The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
451	July 24	Occasionally	?.
705	Aug. 17	.....do	?.

No. 46.

Location.—In front of 1522 Wisconsin avenue NW.
Kind.—Wood.
Condition.—Good; pipe drain to sewer.
Depth.—Below surface, 24 feet; water, 4 feet.
Sewer.—Depth, ?; distance from well, 30 feet.
Privies.—None in block.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.

No. 48.

Location.—Twenty-eighth and O streets NW. (northwest corner).
Kind.—Wood.
Condition.—Good; pipe drain to sewer.
Depth.—Below surface, 30 feet; water, 4 feet.
Sewer.—Depth, 10½ feet; distance from well, 0.
Privies.—One in block.
Bacteriologically.—Indicates sewage pollution.
Chemically.—Remote pollution.
The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
191	June 10	Frequently	?.
779	Sept. 2	.....do	?.

No. 57.

Location.—Thirty-fourth street and Volta place NW. (northwest corner).
Kind.—Wood.
Condition.—Old; cracked; bricks loose at base; overflow at base when pumping.
Depth.—Below surface, 23 feet; water, 2½ feet.
Sewer.—Depth, 9½ feet; distance from well, 15 feet.
Privies.—None within two blocks.
Bacteriologically.—Fair.
Chemically.—Remote pollution.

The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
390	July 19	Frequently	Milk.
642	July 21	....do	?.

No. 58.

Location.—Thirty-fourth street near Wisconsin avenue NW. (west side).
Kind.—Wood.
Condition.—Fair; pipe drain to sewer.
Depth.—Below surface, 22 feet; water, 3 feet.
Sewer.—Depth, 12½ feet; distance from well, 20 feet.
Privies.—Two in block; four others within one and one-half blocks.
Bacteriologically.—Good.
Chemically.—Remote pollution.

No. 67.

Location.—Thirty-fifth and Reservoir streets NW. (southwest corner).
Kind.—Wood.
Condition.—Old; very rotten; bricks loose at base; surface drainage to sewer.
Depth.—Below surface, 25 feet; water, 3 feet.
Sewer.—Depth, 12 feet; distance from well, 40 feet.
Privies.—One in block.
Bacteriologically.—Good.
Chemically.—Remote pollution.
The following 3 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
547	Aug. 9	Occasionally	Milk.
574	Aug. 11	Habitually	Do.
642	July 21	Occasionally	?.

No. 72.

Location.—Third and L streets NW. (northwest corner).
Kind.—Wood.
Condition.—Fair; pipe drain to sewer.
Depth.—Below surface, 18 feet; water, 8 feet.
Sewer.—Depth, 8 feet; distance from well, 20 feet.
Privies.—One in block.
Bacteriologically.—Good.
Chemically.—Polluted.
The following 4 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
348	July 15	Frequently	?.
543	Aug. 1	Occasionally	?.
660	Aug. 20	....do	?.
689	Aug. 23	Frequently	?.

No. 77.

Location.—Sixteenth and Corcoran streets NW. (northwest corner).
Kind.—Wood.
Condition.—Fair.
Depth.—Below surface, 26 feet; water, 3 feet.
Sewer.—Depth, $9\frac{1}{2}$ feet; distance from well, 15 feet.
Privies.—None in block; 3 within two blocks.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.
The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
194	June 1	Occasionally	?.

No. 111.

Location.—New Jersey avenue and Pierce street NW. (southeast corner).
Kind.—Wood.
Condition.—Old; somewhat rotten; bricks loose at base; pipe drain to sewer.
Depth.—Below surface, 18 feet; water, 4 feet.
Sewer.—Depth, 4 feet; distance from well, 0.
Privies.—Five in opposite block.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.
The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
493	Aug. 6	Frequently	?.

No. 127.

Location.—Twelfth street and Florida avenue NW.
Kind.—Wood.
Condition.—Old; bricks loose at base; pipe drain to sewer. (Broken, October 6, 1906.)
Depth.—Below surface, 15 feet; water, 2 feet.
Sewer.—Depth, 11 feet; distance from well, 20 feet.
Privies.—Three within two blocks; none in same block.
Bacteriologically.—Good.
Chemically.—Unpolluted.
The following 3 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
431	July 28	Frequently	?.
816	Sept. 11	....do	?.
941	Oct. 4	Occasionally	?.

No. 128.

Location.—Eighth and Barry place NW. (southwest corner).
Kind.—Wood.
Condition.—Old; rotten upper half; pipe drain to sewer.
Depth.—Below surface, $12\frac{1}{2}$ feet; water, $1\frac{1}{4}$ feet.
Sewer.—Depth, 6 feet; distance from well, 10 feet.
Privies.—One within one block. (Our observation.)
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.
The following 9 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
428	July 28	Frequently	a
429	July 20	do	a
457	July 14	Occasionally	a
473	July 30	Frequently	a
596	Aug. 5	do	?.
742	Sept. 3	do	?.
832	Sept. 20	Occasionally	?.
894	Oct. 1	Frequently	?.
930	Oct. 13	do	?.

[a] This is the most suspicious grouping of cases among the persons using the water of any particular well.

No. 130.

Location.—North Capitol and Randolph streets (southwest corner).
Kind.—Wood.
Condition.—Good; pipe drain to sewer.
Depth.—Below surface, 32 feet; water, 2 feet.
Sewer.—Depth, ?; distance from well, 50 feet.
Privies.—None within four blocks.
Bacteriologically.—Fair.
Chemically.—Unpolluted.

No. 131.

Location.—New Jersey avenue, opposite Morgan place NW. (west side).
Kind.—Wood.
Condition.—Good; pipe drain to sewer.
Depth.—Below surface, 24 feet; water, 3 feet.
Sewer.—Depth, ?; distance from well, 10 feet.
Privies.—One within three blocks.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.
The following 4 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
231	July 2	Frequently	?.
312	July 3	Occasionally	?.
320	July 10	Frequently	?.
484	Aug. 1	Occasionally	?.

No. 169.

Location.—Newton place, east of Brightwood avenue NW. (south side).
Kind.—Wood.
Condition.—Old; cracked; bricks somewhat loose at base; pipe drain to sewer.
Depth.—Below surface, 23 feet; water, 3 feet.
Sewer.—Depth, 8½ feet; distance from well, 10 feet.
Privies.—Eight in block; 20 within one and one-half blocks.
Bacteriologically.—Indicates sewage pollution.
Chemically.—Remote pollution.

No. 170.

Location.—Sixth street, north of Fairmont street NW. (east side).
Kind.—Wood.
Condition.—Rotten; old; bricks loose at base; surface drainage.
Depth.—Below surface, 40 feet; water, 5 feet.
Sewer.—Depth, 10½ feet; distance from well, 20 feet.
Privies.—One within two blocks.
Bacterioiogically.—Good.
Chemically.—Remote pollution.

No. 175.

Location.—In front of 1685, Wisconsin avenue and Thirty-third street NW.
Kind.—Wood.
Condition.—New; pipe drain to sewer.
Depth.—Below surface, 22 feet; water, 3 feet.
Sewer.—Depth, 5 feet; distance from well, 5 feet.
Privies.—Two in block.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Unpolluted.
NOTE.—Reservoir on hill.

No. 202.

Location.—Zoological Park; near Chevy Chase entrance.
Kind.—Special iron.
Condition.—Fair; poor flow of water.
Depth.—No data.
Sewer.—None in neighborhood.
Privies.—None in neighborhood.
Bacteriologically.—Indicates sewage pollution.
Chemically.—Polluted.

No. 204.

Location.—Massachusetts avenue near Wisconsin avenue NW. (east side).
Kind.—Wood.
Condition.—Good; mounted on brick base; surface drainage.
Depth.—Below surface, 28 feet; water (?).
Sewer.—Depth, (?); distance from well, 1,000 feet.
Privies.—None within six blocks.
Bacteriologically.—Fair.
Chemically.—Polluted.

No. 226.

Location.—Brightwood avenue near District line, in front of Jones's blacksmith shop.
Kind.—Wood.
Condition.—Very bad; surface drainage.
Depth.—Below surface, 18 feet; water, 3 feet.
Sewer.—None in neighborhood.
Privies.—None in neighborhood (?).
Bacteriologically.—Indicates surface pollution; variable.
Chemically.—Unpolluted.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
495	July 31	Occasionally	Contact with case out of District of Columbia.

No. 235.

Location.—Hurst and Elliott places NW. (northeast corner).
Kind.—"Common sense;" new, 1901.
Condition.—Good.
Depth.—Below surface, 27½ feet; water, 4½ feet.
Sewer.—None in neighborhood; canal about 100 feet distant.
Privies.—Two within two blocks.
Bacteriologically.—Indicates surface contamination.
Chemically.—Polluted.

Location.—Tenleytown road, Tenleytown, D. C.
Kind.—Wood.
Condition.—Broken; not in use this summer.
Depth.—No data.
Sewer.—None in neighborhood.
Privies.—There are about 45 north and northeast of the well, the nearest being about three blocks away; 1 in same block.

Location.—Fort Slocum School, Lamont's, Blair road, Takoma, D. C.
Depth.—No data.
Sewer.—None in neighborhood.
Privies.—Nearest, three blocks.

SHALLOW WELLS—NORTHEAST SECTION.

No. 23.

Location.—Third and D streets NE. (northwest corner).
Kind.—Wood.
Condition.—Fair; pipe drain to sewer.
Depth.—Below surface, 24 feet; water, 3 feet.
Sewer.—Depth, 12½ feet; distance from well, 0 feet.
Privies.—None in block; 5 within two blocks.
Bacteriologically.—Fair.
Chemically.—Remote pollution.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
709	Aug. 26	Occasionally	?.

No. 24.

Location.—Fourth and E streets NE. (northwest corner).
Kind.—Wood.
Condition.—Rotten at base; pipe drain to sewer.
Depth.—Below surface, 26 feet; water, 4 feet.
Sewer.—Depth, 9¾ feet; distance from well, 10 feet.
Privies.—One in block diagonally opposite.
Bacteriologically.—Indicates sewage pollution: variable.
Chemically.—Polluted.

No. 26.

Location.—Second and G streets NE. (northeast corner).
Kind.—Wood.
Condition.—Old; pipe drain to sewer.
Depth.—Below surface, 29 feet; water, 3½ feet.
Sewer.—Depth, 9 feet; distance from well, 20 feet.
Privies.—None in block; 2 within two blocks.
Bacteriologically.—Fair.
Chemically.—Remote pollution.
The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
314	July 10	Frequently	?
337	July 15	do	?

No. 28.

Location.—Sixth and C streets NE. (northwest corner).
Kind.—Wood.
Condition.—Old, cracked, rotten at base; pipe drain to sewer.
Depth.—Below surface, 34 feet; water, 5 feet.
Sewer.—Depth, 9½ feet; distance from well, 50 feet.
Privies.—None within two blocks.
Bacteriologically.—Fair.
Chemically.—Remote pollution.

No. 38.

Location.—E street between Eighth and Ninth streets NE. (north side).
Kind.—Wood.
Condition.—Cracked, rotten at base; surface drainage to sewer.
Depth.—Below surface, 18 feet; water, 4 feet.
Sewer.—Depth, 9½ feet; distance from well, 10 feet.
Privies.—None in block; 2 within two and one-half blocks.
Bacteriologically.—Indicates surface contamination; variable.
Chemically.—Polluted.

No. 40.

Location.—Eighth and A streets NE. (southwest corner).
Kind.—Wood.
Condition.—Old, rotten lower third; pipe drain to sewer.
Depth.—Below surface, 22 feet; water, 6 feet.
Sewer.—Depth, 8 feet; distance from well, 10 feet.
Privies.—None within three blocks.
Bacteriologically.—Fair.
Chemically.—Polluted.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection
759	Sept. 1	Habitually	?

No. 109.

Location.—North Capitol, between B and C streets NE.
Kind.—Wood.
Condition.—Good; pipe drain to sewer.
Depth.—Below surface, 27½ feet; water, 3 feet.
Sewer.—Depth, ?; distance from well, 50 feet.
Privies.—One in same block; 1 school with Smead system within two blocks.
Bacteriologically.—Fair.
Chemically.—Remote pollution.

No. 129.

Location.—Keating place, between Lincoln avenue and First street NE. (north side).
Kind.—Wood.
Condition.—Old; rotten; mounted on brick base, some of the bricks being loose; surface drainage to sewer.
Depth.—No data.
Sewer.—Depth 9½ feet; distance from well, 20 feet.
Privies.—None within three blocks.
Bacteriologically.—Good.
Chemically.—Remote pollution.

No. 135.

Location.—Eleventh and F streets NE. (northwest corner).
Kind.—Wood.
Condition.—Fair; pipe drain to sewer.
Depth.—Below surface, 20 feet; water, 8 feet.
Sewer.—Depth, 10 feet; distance from well, 50 feet.
Privies.—One in opposite block.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
801	Sept. 13	Habitually	?.

No. 217.

Location.—Benning Crossroads, in front of Hotel Benning.

Kind.—Wood.

Condition.—Old; bricks loose at base; pipe drain to horse trough. (October 12, 1906, pump in bad condition).

Depth.—Below surface, 21 feet; water, 3 feet.

Sewer.—None in neighborhood.

Privies.—One in block; 1 other within two blocks.

Bacteriologically.—Indicates sewage pollution.

Chemically.—Polluted.

No. 218.

Location.—Benning School.

Kind.—Septical iron.

Condition.—Mounted on wooden base in pump house; drainage to surface by trough; good. (October 12, 1906, reported not used; water has bad odor.)

Depth.—No data.

Sewer.—None in neighborhood.

Privies.—One in block; 2 within two blocks.

Bacteriologically.—Indicates sewage pollution.

Chemically.—Polluted.

No. 224.

Location.—Quincy (Philadelphia) street, between Thirteenth and Fourteenth streets NE., Brookland, D. C.

Kind.—Wood.

Condition.—Fair; bricks loose at base; surface drainage.

Depth.—Below surface, 17 feet; water, 5¼ feet.

Sewer.—None in neighborhood.

Privies.—None within four blocks.(?)

Bacteriologically.—Fair.

Chemically.—Unpolluted.

No. 225.

Location.—South Dakota avenue and Vista street NE., Woodridge, D. C.

Kind.—Wood.

Condition.—Pump proper in fair condition; mounted on wooden base, between which and ground level some of the bricks of the well are missing, leaving a hole directly into the well; surface drainage.

Depth.—Below surface, 20 feet; water, 15 feet.

Sewer.—None in neighborhood.

Privies.—None shown within several blocks.

Bacteriologically.—Indicates sewage pollution.

Chemically.—Polluted.

SHALLOW WELLS—SOUTHWEST SECTION.

No. 104.

Location.—South Capitol and M streets (southwest corner) in Ford's brickyard. Pump is private property, but is used by public.

Kind.—Wood.

Condition.—Good; mounted on wooden base; leaking back into well apparently very easy; surface drainage by means of wooden trough.

Depth.—No data.

Sewer.—Depth, 11 feet; distance from well, 25 feet (?).
Privies.—Eight in block; 20 within one and one-half blocks.
Bacteriologically.—Indicates sewage pollution.
Chemically.—Polluted.

The following four cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
171	May 18	Habitually	?.
226	June 21	Occasionally	?.
446	Aug. 2	Frequently	?.
754	Sept. 12	Occasionally	?.

SHALLOW WELLS—SOUTHEAST SECTION.

No. 30.

Location.—Fourth street and South Carolina avenue SE. (southwest corner).
Kind.—
Condition.—Old; cracked; bricks loose at base; pipe drain to sewer.
Depth.—Below surface, 21 feet; water, 3 feet.
Sewer.—Depth, 10½ feet; distance from well, 50 feet.
Privies.—Two in block.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Polluted.

No. 32.

Location.—Fifth and G streets SE. (northeast corner).
Kind.—Wood.
Condition.—Rotten at base; bricks loose at base; pipe drain to sewer.
Depth.—Below surface, 14 feet; water, 2 feet.
Sewer.—Depth, 8 feet; distance from well, 10 feet.
Privies.—None in block; 3 within one block radius.
Bacteriologically.—Indicates sewage pollution; variable.
Chemically.—Remote pollution.
The following 4 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
169	July 6	Frequently	?.
290	July 14	Occasionally	?.
450	Aug. 1	.....do	?.
723	Aug. 25	.....do	?.

No. 34.

Location.—Fourth street and North Carolina avenue, Seward square, SE. (southeast corner).
Kind.—Wood.
Condition.—Fair.
Depth.—Below surface, 20 feet; water, 3 feet.
Sewer.—Depth, 6 feet; distance from well, 10 feet.
Privies.—None within two blocks.
Bacteriologically.—Good.
Chemically.—Remote pollution.

No. 35.

Location.—Third and C streets SE. (southwest corner).

Kind.—Wood.

Condition.—Fair, but poor stream; sediment in first water drawn; pipe drain to sewer.

Depth.—Below surface, 26 feet 8 inches; water, 3 feet 3 inches.

Sewer.—Depth, 12 feet; distance from well, 10 feet.

Privies.—None within two blocks.

Bacteriologically.—Indicates sewage pollution; variable.

Chemically.—Polluted.

No. 91.

Location.—Harrison street, between Seventeenth and Eighteenth SE. (south side).

Kind.—Wood.

Condition.—Fair; bricks loose at base; surface drainage to sewer.

Depth.—Below surface, 12 feet; water, 6 feet.

Sewer.—Depth, 11 feet; distance from well, 20 feet.

Privies.—None in block; 2 within one and one-half blocks.

Bacteriologically.—Indicates sewage pollution; variable.

Chemically.—Polluted.

The following 2 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
837	Sept. 10	Frequently	?.
874	Sept. 9	.....do	?.

No. 92.

Location.—Seventh and B streets SE. (northwest corner).

Kind.—Wood.

Condition.—Old; bricks loose at base; pipe drain to sewer.

Depth.—Below surface, 33 feet; water, 3 feet.

Sewer.—Depth, 12 feet; distance from well, 15 feet.

Privies.—None within three blocks.

Bacteriologically.—Good.

Chemically.—Remote pollution.

No. 101.

Location.—Third street and Pennsylvania avenue SE. (southwest corner).

Kind.—Wood.

Condition.—Fair; pipe drain to sewer.

Depth.—Below surface, 28 feet; water, 4 feet.

Sewer.—Depth, 18 feet; distance from well, 40 feet.

Privies.—None in block; 1 in opposite block.

Bacteriologically.—Indicates surface contamination.

Chemically.—Polluted.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
638	Aug. 13	Occasionally	?.

No. 102.

Location.—In front of 220 Seventh street, between B and C, SE.
Kind.—Wood.
Condition.—Relatively new; bricks loose at base; pipe drain to sewer.
Depth.—Below surface, 27 feet; water, 4 feet.
Sewer.—Depth, 8 feet; distance from well, 50 feet.
Privies.—None within three blocks.
Bacteriologically.—Good.
Chemically.—Remote pollution.
The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
436	July 21	Frequently	?.

No. 103.

Location.—Eighth and D streets SE. (northwest corner).
Kind.—Wood.
Condition.—Old; rotten at base; bricks loose at base; pipe drain to sewer.
Depth.—Below surface, 28 feet; water, 3 feet.
Sewer.—Depth, 10 feet; distance from well, 10 feet.
Privies.—None in block; 1 within two blocks.
Bacteriologically.—Fair.
Chemically.—Remote pollution.

No. 116.

Location.—Jefferson street between Monroe and Fillmore SE. (north side).
Kind.—Wood.
Condition.—Old; rotten; bricks loose at base; surface drainage to sewer.
Depth.—Below surface, 17¼ feet; water, 4¼ feet.
Sewer.—Depth, 10 feet; distance from well, 0 foot.
Privies.—One in opposite block.
Bacteriologically.—Good.
Chemically.—Polluted.

No. 117.

Location.—Fillmore and Jackson streets SE. (southwest corner).
Kind.—Wood.
Condition.—Good; pipe drain to sewer.
Depth.—No data.
Sewer.—Depth, 10½ feet; distance from well, 20 feet.
Privies.—One in block; 2 within one and one-half blocks.
Bacteriologically.—Good.
Chemically.—Remotely polluted.
The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
480	July 17	Occasionally	?.

No. 139.

Location.—L street between Thirteenth and Fourteenth streets SE. (south side).

Kind.—Wood.

Condition.—Fair; bricks loose at base; water obtained only after long pumping and very little used; surface drainage.

Depth.—Below surface, 25 feet; water, 4 feet.

Sewer.—Depth, 12 feet; distance from well, 40 feet.

Privies.—Seven in block; 11 within one and one-half blocks.

Bacteriologically.—Indicates sewage pollution; variable.

Chemically.—Polluted.

No. 145.

Location.—Eleventh street and South Carolina avenue SE. (southwest corner).

Kind.—Wood.

Condition.—Old; slightly rotten at base; poor stream of water; pipe drain to sewer.

Depth.—Below surface, 28 feet; water, 4 feet.

Sewer.—Depth, 8 feet; distance from well, 60 feet.

Privies.—One in opposite block.

Bacteriologically.—Indicates sewage pollution; variable.

Chemically.—Polluted.

The following case of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
774	Sept. 5	Frequently	?.

No. 146.

Location.—I street, between Eleventh and Twelfth streets SE. (south side).

Kind.—Wood.

Condition.—Old; pipe drain to sewer.

Depth.—Below surface, 26 feet; water, 15 feet.

Sewer.—Depth, 10 feet; distance from well, 30 feet.

Privies.—One in opposite block.

Bacteriologically.—Fair.

Chemically.—Remote pollution.

The following 4 cases of typhoid fever drank the water of this well:

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection.
180	June 5	Frequently	?.
315	July 15	Occasionally	?.
397	July 25	do	?.
445	July 28	do	?.

No. 183.

Location.—Hamilton road, opposite Jewish Cemetary, Hillsdale, D. C.

Kind.—Wood.

Condition.—Good; set on brick base; surface drainage, not connected with sewage system.

Depth.—No data.

Sewer.—None in neighborhood.

Privies.—None within over three blocks.

Bacteriologically.—Indicates sewage pollution; variable.

Chemically.—Polluted.

No. 185.

Location.—Stanton avenue and Pomeroy street, Hillsdale, D. C.

Kind.—Wood.

Condition.—Fair; bricks loose at base; surface drainage; water does not drain away freely.

Depth.—Below surface, 18 feet; water, 6 feet.

Sewer.—None in neighborhood.

Privies.—Three within three blocks.

Bacteriologically.—Good.

Chemically.—Polluted.

No. 208.

Location.—Stanton School, Good Hope, D. C.

Kind.—Iron, special.

Condition.—Mounted on wooden base the boards of which do not fit closely; drainage to surface by wooden trough.

Depth.—No data.

Sewer.—None in neighborhood.

Privies.—None for several blocks.

Bacteriologically.—Fair.

Chemically.—Polluted.

No. 209.

Location.—Twentieth and Joliet streets SE. (Garfield Heights, D. C.).

Kind.—Wood.

Condition.—New; set on brick base; surface drainage; not connected with sewage system.

Depth.—No data.

Sewer.—None in neighborhood.

Privies—None for over five blocks.

Bacteriologically.—Indicates sewage pollution; variable.

Chemically.—Polluted.

No. 385.

Location.—T Street hill, Hillsdale, D. C.

Kind.—Iron.

Condition.—Out of order; handle gone; bricks loose at base; surface drainage; does not connect with sewage system. (October 8, 1906, new wood pump, iron casing 10 inches above ground; slope from well.)

Depth.—No data.

Sewer.—None in neighborhood.

Privies.—Three within two blocks.

Bacteriologically.—Fair.

Chemically.—Polluted.

No. 422.

Location.—Ninth and E streets SE. (southeast corner).

Kind.—Wood.

Condition.—Old, out of order; pipe drain to sewer. (Pump O. K., October 11, 1906.)

Depth.—Below surface, 25 feet; water, 6 feet.

Sewer.—Depth, 18 feet; distance from well, 10 feet.
Privies.—None within two blocks.
Bacteriologically.—Indicates sewage pollution.
Chemically.—Polluted.

Location.—Thirteenth street between D and E streets SE. (west side).
Condition.—Out of order.
Depth.—Below surface, 30 feet; water, 4 feet.
Sewer.—Depth, 11 feet; distance from well, 100 feet.
Privies.—Ten in opposite block; 3 others within two blocks.
The following case of typhoid fever drank the water of this well.

Case No.	Onset of disease.	During the 30 days preceding onset of disease used the well water—	Probable source of infection
207	June 20	Frequently	?.

Location.—O street, between Half and First streets SE. (north side).
Kind.—Wood.
Condition.—Broken; not in use since last summer.
Depth.—Below surface, 20 feet; water, 4 feet.
Privies.—Eight in block; 15 within one and one-half blocks.
Sewer.—Depth, 11 feet; distance from well, 0 feet.

Location.—Elvan avenue, west of Stanton avenue.
Kind.—Iron.
Condition.—Out of order; residents say water not fit to drink when obtainable.
Depth.—No data.
Sewer.—None in neighborhood.

Bacteriology of the shallow wells in the District of Columbia.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Ferment in lac-bouillon.			B. coli present.		
				0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.
	Northwest.	1906.							
5	Sixth, between F and G streets	July 16	60	−	−	−	−	−	−
378	....do	Oct. 5	7	......	−	−	−	−	−
L	....do	July 7	7	......	......	......	−	−	−
6	Ninth and H streets	July 16	80	−	−	−	−	−	−
377	....do	Oct. 5	42	......	−	−	−	−	−
L	....do	July 7	8	......	......	......	−	−	−
8	Tenth and N streets	July 17	500	+	+	+	+	+	+
358	....do	Oct. 3	590	......	−	−	−	−	−
L	....do	July 7	215	......	......	......	−	−	+
9	Tenth and K streets	July 17	350	−	+	+	......	+	+
359	....do	Oct. 3	139	......	−	+	......	......	+
L	....do	July 5	75	......	......	......	−	−	−
11	Seventeenth and K streets	July 17	127	−	−	−	−	−	−
372	....do	Oct. 5	18	......	−	−	−	−	−
L	....do	June 26	50	......	......	......	−	−	−
13	Third street and Indiana avenue	July 18	44	−	−	−	−	−	−
376	....do	Oct. 5	43	......	−	+	......	......	+
L	....do	July 7	20	−	−	−	−	−	−

Bacteriology of the shallow wells in the District of Columbia—Continued.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Ferment in lac-bouillon.			B. coil present.		
				0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.
	Northwest—Continued.								
14	New York avenue, between Fourth and Fifth streets	1906. July 18	52	–	–	–	–	–	–
360	......do	Oct. 3	174	......	–	–	–	–	–
L	......do	July 7	43	......	......	......	–	–	–
15	Massachusetts avenue, between Sixth and Seventh streets	July 18	87	–	–	–	–	–	–
329	......do	Sept. 26	400	–	+	+	–	–	–
375	......do	Oct. 5	182	......	+	+	......	......	+
L	......do	July 7	61	......	......	......	–	–	+
44	Wisconsin avenue and Q street	July 25	92	–	–	–	–	–	–
369	......do	Oct. 4	17	......	–	–	–	–	–
L	......do	June 26	5	......	......	......	–	–	–
45	Facing 1614 Thirty-second street	July 25	380	–	–	–	–	–	–
311	......do	Sept. 20	36	......	–	–	–	–	–
334	......do	Sept. 26	10	–	–	–	–	–	–
370	......do	Oct. 4	12	......	–	–	–	–	–
L	......do	July 5	2	......	......	......	–	–	–
46	Facing 1522 Wisconsin avenue	July 25	110	+	+	+	+	+	+
365	......do	Oct. 4	111	......	–	–	–	–	–
L	......do	July 5	140	......	......	......	+	+	+
46	Opposite 1522 Wisconsin avenue	July 5	140	......	......	......	+	+	+
		Aug. 4	1,400	......	......	......	–	–	–
		Aug. 6	260	......	......	......	–	–	–
		Aug. 16	31	......	......	......	–	–	–
		Aug. 17	60	......	......	......	–	+	+
		Aug. 18	30	......	......	......	–	–	–
		Aug. 20	27	......	......	......	–	–	–
48	Twenty-eighth and O streets	July 25	1,000	+	+	+	+	+	+
364	......do	Oct. 4	220	......	–	+	......	......	+
L	......do	July 5	85	......	......	......	–	+	–
57	Thirty-fourth street and Volta place	July 27	194	–	–	–	–	–	–
58	Thirty-fourth street and Wisconsin avenue	July 27	3	–	–	–	–	–	–
367	......do	Oct. 4	2	......	–	–	–	–	–
L	......do	July 18	16	......	......	......	–	–	–
67	Thirty-fifth and Reservoir streets	July 31	1	–	–	–	–	–	–
366	......do	Oct. 4	22	......	–	–	–	–	–
L	......do	June 26	16	......	......	......	–	–	–
72	Third and L streets	Aug. 1	15	–	–	–	–	–	–
361	......do	Oct. 3	2	......	–	–	–	–	–
L	......do	July 7	9	......	......	......	–	–	–
77	Sixteenth and Corcoran streets	Aug. 2	37	–	–	–	–	–	–
314	......do	Sept. 21	50	–	–	–	–	–	–
373	......do	Oct. 5	12	......	–	–	–	–	–
L	......do	July 7	7	......	......	......	–	–	+
111	New Jersey avenue and Pierce street	Aug. 9	8	–	–	–	–	–	–
331	......do	Sept. 26	43	–	+	+	......	......	+
362	......do	Oct. 3	630	......	–	+	......	......	+
L	......do	July 7	119	......	......	......	–	–	+
120	Chevy Chase spring	Aug. 13	370	–	+	+	......	+	......
159	......do	Aug. 21	240	–	–	+	......	......	+
L	......do	......	......	......	......	......	......	......	......

Bacteriology of the shallow wells in the District of Columbia—Continued.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Ferment in lac-bouillon. 0.1 cc.	1 cc.	10 cc.	B. coli present. 0.1 cc.	1 cc.	10 cc.
	Northwest—Continued.	1906.							
121	Chevy Chase well	Aug. 13	2	—	—	—	—	—	—
158	....do	Aug. 21	60	—	—	—	—	—	—
127	Twelfth street and Florida avenue	Aug. 14	1	—	—	—	—	—	—
L	....do	July 7	8	......	......	......	—	—	—
128	Eighth street and Barry place	Aug. 14	(?)	—	—	—	—	—	—
171	....do	Aug. 22	(?)	—	—	+	......	......	+
383	....do	Oct. 6	132	—	—	—	—	—	—
L	....do	July 7	128	......	......	......	—	—	+
		....do	128	......	......	......	—	—	+
		Aug. 4	95	......	......	......	—	—	—
		Aug. 6	38	......	......	......	—	—	—
		Aug. 7	25	......	......	......	—	—	—
		Aug. 8	34	......	......	......	—	—	—
		Aug. 9	31	......	......	......	—	+	+
		Aug. 10	21	......	......	......	—	—	—
128	....do	Aug. 11	22	......	......	......	—	—	—
		Aug. 13	90	......	......	......	—	—	+
		Aug. 14	35	......	......	......	—	—	—
		Aug. 15	55	......	......	......	—	—	+
		Aug. 16	2	......	......	......	—	—	+
		Aug. 17	28	......	......	......	—	—	—
		Aug. 18	34	......	......	......	—	—	—
		Aug. 20	29	......	......	......	—	—	—
130	North Capitol and Randolph streets	Aug. 14	23	—	—	—	—	—	—
381	....do	Oct. 6	128	—	—	—	—	—	—
L	....do	July 7	38	......	......	......	—	—	—
131	New Jersey and Morgan avenues	Aug. 14	6	—	—	—	—	—	—
330	....do	Sept. 26	13	—	—	—	—	—	—
363	....do	Oct. 3	7	......	—	—	—	—	—
L	....do	July 7	17	......	......	......	—	—	+
169	Newton street, east of Brightwood	Aug. 22	200	—	—	+	......	......	+
427	....do	Oct. 11	98	......	+	+	......	......	+
L	....do	July 7	3	......	......	......	—	—	+
170	Sixth street, north of Fairmont	Aug. 22	20	—	—	—	—	—	—
382	....do	Oct. 6	26	—	—	—	—	—	—
L	....do	July 7	12	......	......	......	—	—	—
175	Thirty-third street and Wisconsin avenue	Aug. 23	450	+	+	+	......	+	......
368	....do	Oct. 4	102	......	—	—	—	—	—
L	....do	July 18	107	......	......	......	—	—	—
201	Zoo, near office	Aug. 28	(a ?)	+	+	+	......	......	+
202	Zoo, pump	....do	200	—	+	+	—	—	—
203	Zoo, near refreshment stand	....do	a 120	+	—	+	......	......	+
204	Massachusetts avenue, near Wisconsin avenue	....do	21	—	—	—	—	—	—
454	....do	Oct. 15	224	......	—	......	—	—	—
L	....do	July 18	55	......	......	......	—	—	—
226	Brightwood avenue, facing Jones's blacksmith shop	Aug. 31	820	—	+	+	—	—	—
441	....do	Oct. 13	246	......	+	+	......	+	......

a In 1 cc ?.

Bacteriology of the shallow wells in the District of Columbia—Continued.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Ferment in lac-bouillon.			B. coli present.		
				0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.
	Northwest—Continued.	1906.							
235	Hurst and Elliott streets	Sept. 4	123	−	+	+	−	−	−
455	....do	Oct. 15	56	......	−	......	−	−	−
L	....do	Aug. 3	675	......	......	......	−	−	−
	Southwest.								
104	South Capitol and M streets, Ford brickyard	Aug. 8..	1,800	+	+	+	......	+	+
	Northeast.								
23	Third and D streets	July 20	86	−	−	−	−	−	−
418	....do	Oct. 10	224	......	−	−	−	−	−
L	....do	July 7	21	......	......	......	−	−	−
24	Fourth and E streets	July 20	281	−	+	+	......	......	(?)
37	....do	July 24	201	−	−	+	......	......	+
148	....do	Aug. 17	10	−	−	−	−	−	−
413	....do	Oct. 10	11	......	−	−	−	−	−
L	....do	July 7	46	......	......	......	......	......	+
26	Second and G streets	July 20	106	−	−	−	−	−	−
412	....do	Oct. 10	68	......	−	−	−	−	−
L	....do	July 7	5	......	......	......	−	−	−
28	Sixth and C streets	July 20	84	−	−	−	−	−	−
417	....do	Oct. 10	8	......	−	−	−	−	−
L	....do	July 7	102	......	......	......	−	−	−
38	E, between Eighth and Ninth streets..	July 24	56	−	−	−	−	−	−
415	....do	Oct. 10	3,500	......	+	−	−	−	−
L	....do	July 10	2	......	......	......	−	−	−
40	Eighth and A streets	July 24	22	−	−	−	−	−	−
426	....do	Oct. 11	50	......	−	−	−	−	−
L	....do	July 21	11	......	......	......	−	−	−
109	North Capitol, between B and C streets.	Aug. 9	33	−	−	−	−	−	−
374	....do	Oct. 5	80	......	−	−	−	−	−
L	....do	July 7	21	......	......	......	−	−	−
129	Keating, between Lincoln and First streets	Aug. 14	4	−	−	−	−	−	−
407	....do	Oct. 9	8	......	−	−	−	−	−
135	Eleventh and F streets	Aug. 15	(?)	−	+	+	......	+	......
416	....do	Oct. 10	362	......	−	−	−	−	−
L	....do	July 10	7	......	......	......	−	+	+
217	Bennings Crossroads	Aug. 30	217	−	+	+	......	+	......
435	....do	Oct. 12	2,500	......	+	+	......	+	......
218	Bennings School	Aug. 30	860	+	+	+	......	+	......
436	....do	Oct. 12	192	......	(?)	−	−	−	−
224	Old Philadelphia (Quincy) street between Twelfth and Thirteenth streets	Aug. 31	210	−	−	−	−	−	−
406	....do	Oct. 9	43	......	−	−	−	−	−
225	South Dakota avenue and Vista street.	Aug. 31	[a] 530	−	+	+	......	......	+
405	....do	Oct. 9	675	......	−	+	......	......	+

[a] In 1 cc.?

Bacteriology of the shallow wells in the District of Columbia—Continued.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Ferment in lac-bouillon.			B. coli present.		
				0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.
	Southeast.	1906.							
30	Fourth and South Carolina avenue	July 23	512	+	+	+	+	+	+
144	.....do	Aug. 17	6	—	—	—	—	—	—
395	.....do	Oct. 9	140	......	—	—	—	—	—
L	.....do	July 10	26	......	......	......	—	—	—
32	Fifth and G streets	July 23	a 67	—	+	+	......	+	+
147	.....do	Aug. 17	100	—	—	—	—	—	—
396	.....do	Oct. 9	110	......	—	—	—	—	—
L	.....do	July 10	5	......	......	......	—	—	—
34	Fourth and Seward square	July 23	32	—	—	—	—	—	—
397	.....do	Oct. 9	9	......	—	—	—	—	—
L	.....do	July 10	6	......	......	......	—	—	—
35	Third and C streets	July 23	321	—	—	+	......	......	+
398	.....do	Oct. 9	27	......	—	—	—	—	—
L	.....do	July 10	2	......	......	......	—	—	—
91	Seventeenth and Harrison streets, Anacostia.	Aug. 6	123	+	+	+	+	+	+
393	.....do	Oct. 8	185	......	—	—	—	—	—
L	.....do	July 26	340	......	......	......	—	+	—
92	Seventh and B streets	Aug. 6	15	—	—	—	—	—	—
423	.....do	Oct. 11	43	......	—	—	—	—	—
L	.....do	July 10	5	......	......	......	—	—	—
101	Third street and Pennsylvania avenue	Aug. 8	65	—	—	—	—	—	—
399	.....do	Oct. 9	360	......	—	+	—	—	—
473	.....do	Oct. 9	552	......	+	+	—	—	—
L	.....do	July 10	4	......	......	......	—	—	—
102	Seventh, between B and C streets	Aug. 8	20	—	—	—	—	—	—
424	.....do	Oct. 11	19	......	—	—	—	—	—
L	.....do	July 10	1	......	......	......	—	—	—
103	Eighth and D streets	Aug. 8	28	—	—	—	—	—	—
L	.....do	July 10	104	......	......	......	—	—	—
116	Jefferson, between Monroe and Fillmore streets.	Aug. 10	63	—	—	—	—	—	—
386	.....do	Oct. 8	67	......	—	—	—	—	—
L	.....do	July 26	15	......	......	......	—	—	—
117	Fillmore and Jackson streets	Aug. 10	27	—	—	—	—	—	—
387	.....do	Oct. 8	76	......	—	—	—	—	—
L	.....do	July 26	2	......	......	......	—	—	—
139	L, between Thirteenth and Fourteenth streets.	Aug. 16	(?)	—	—	+	......	......	+
442	.....do	Oct. 13	22	......	—	—	—	—	—
L	.....do	......	......	......	......	......	......	......	......
145	Eleventh street and South Carolina avenue.	Aug. 17	25	—	—	—	—	—	—
425	.....do	Oct. 11	9	......	+	+	......	+	......
L	.....do	July 10	2	......	......	......	—	—	—
146	I, between Eleventh and Twelfth streets.	Aug. 17	27	—	—	—	—	—	—
444	.....do	Oct. 13	157	......	—	—	—	—	—
L	.....do	July 10	6	......	......	......	—	—	—
183	Hamilton road	Aug. 24	26	—	+	+	......	+	......
389	.....do	Oct. 8	665	......	—	—	—	—	—
185	Stanton and Pomeroy streets	Aug. 24	9	—	—	—	—	—	—

a No indol.

Bacteriology of the shallow wells in the District of Columbia—Continued.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Ferment in lac-bouillon.			B. coli present.		
				0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.
	Southeast—Continued.	1906.							
390	Stanton and Pomeroy streets	Oct. 8	68	......	—	—	—	—	—
L	.....do	July 26	....	......	......	......	......	......	......
208	Stanton School	Aug. 29	19	—	—	—	—	—	—
391	.....do	Oct. 8	500	......	—	—	—	—	—
L	.....do	July 26	620	......	......	......	—	—	—
209	Twentieth and Joliet streets	Aug. 29	26,250	+	+	+	—	—	—
300	.....do	Sept. 19	241	—	—	+	......	......	+
392	.....do	Oct. 8	110	......	—	—	—	—	—
L	.....do	July 26	270	......	......	......	—	—	—
385	T Street hill	Oct. 8	97	......	—	—	—	—	—
422	Ninth and E streets	Oct. 11	20	......	—	+	......	......	+
L	.....do	July 10	....	......	......	......	......	......	......

NOTE.—In these tables the number in the first column refers to our laboratory number. The analyses marked "L" were made by Mr. F. F. Longley, chief chemist and assistant superintendent of the filtration plant. The latter data are included for completeness and comparison, and have been furnished through the kindness of Capt. Spencer Cosby, U. S. Army.

For miscellaneous water supplies, such as Soldiers' Home, St. Elizabeth's, Chevy Chase, etc., and for details of chemical analyses of all these well waters, see Section XII, pages 360 and 328.

V.—SANITARY INSPECTION OF THE TABLE WATERS VENDED IN WASHINGTON, D. C.

SANITARY INSPECTION OF THE TABLE WATERS VENDED IN WASHINGTON, D. C.

By Joseph Goldberger.
Passed Assistant Surgeon, Public Health and Marine-Hospital Service.

SUMMARY.

There is on sale in the city of Washington a great variety of "mineral" waters, both foreign and domestic. One dealer publishes a list of more than sixty names. It was obviously impracticable to make a study of all of these, nor was it necessary for the purposes of this inquiry. The inspection was confined to those table waters originating in or near the city or bottled here. These were studied as to their source and as to the mode of purveyance, and samples were taken for chemical and bacteriological examination with a view of discovering any possible contamination.

Two waters gave evidence of pollution on chemical and bacteriological examination.

The claims of some dealers as to sterilization of their water bottles could not be substantiated.

In a few instances the inspection disclosed objectionable sanitary conditions and methods, and some practices which are calculated to mislead the consumer as to the source or character of the water, but it failed to disclose any conditions which could be regarded as responsible for the prevalence of any part of the typhoid fever in Washington.

DETAILS OF INSPECTION.

NATIONAL WATER COMPANY, GENEVA LITHIA WATER DEPOT.

[M. L. Harper, 737 Eleventh street, NW.]

This firm sells all kinds of mineral waters, of which "Tate Epsom Spring," "Otterburn Lithia," and "Powhatan Spring" are bottled on the premises. It also manufactures and bottles distilled water for table use.

Bottling.—This is done in the cellar under the store where the business is conducted. The cellar is a crude one, with unpaved dirt floor and with the joists supporting the board floor of the store for a ceiling. Thick layers of dust were much in evidence.

The bottles used are secondhand and bought from grocers and private families. They are washed inside and out with ordinary tap water, using sand with the water jet for the interior when the condition of the bottle demands it. After a final rinsing with the tap water and draining the bottle is ready for filling.

The bottles are filled from carboys or barrels by siphonage through a rubber tube. The siphon action is started by suction with the mouth. After filling, the bottles are stoppered with corks which are mostly new, but old corks before being used again are washed in a stream of hot water.

Distilled water.—The boiler used for heating the place of business is also used for generating the steam which is used for making the distilled water. The steam is condensed in a jacketed coil of iron pipe and the water collected and cooled in a galvanized-iron tank, which was loosely covered with a sheet of the same material. The tank is in a closet partitioned off from the room back of the store. From the tank a pipe runs through the floor into the cellar where the bottling is done. The bottling of the distilled water differs from the the method above described, in that the distilled water is run directly into the bottles by gravity, being strained through cheese cloth in the process. The specimen of this water (No. 470) [a], obtained by purchase over the counter, shows both bacteriologically and chemically lack of cleanliness in handling.

Powhatan Spring water.—This water is hauled in 5-gallon carboys from the spring, which is about 2 miles west of Ballston, Va.

The spring is at the base of a wooded hillside, at the top of which a frame house was being erected at the time of the inspection. It is protected on three sides and above by brickwork. The water collects in a sort of shallow basin, from which it flows through an iron pipe to an adjacent dilapidated spring house, in which there stood at the time of inspection an iron kettle containing some decomposing and evil-smelling flesh. The appearance of the place indicated neglect.

A sample (No. 429) of the water taken as it flowed from the pipe in the spring house and examined chemically and bacteriologically showed no evidence of pollution.

GREAT BEAR SPRING WATER.

[Office, 704 Eleventh street NW.]

The spring is in Oswego County, N. Y. The water is brought to the city by rail in sealed iron tanks said to be cement lined, from which it is pumped into similar storage tanks at First and I streets SE., where the bottling is done.

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[a] Laboratory number under which the bacteriological and chemical examination was made, and which will be found in the appended table.

Bottling.—The bottling is done in a large well-aired place, the ground floor of a small brick building, open to the street. Returned bottles are used and are washed in spring water which has been heated in a hot-water boiler. They are filled direct from taps connected with the storage tanks and immediately stoppered and sealed.

Glass stoppers are used for the half-gallon bottles and corks for those of larger sizes; these, when old, are washed before using.

A chemical and bacteriological examination of a sample (No. 457) taken from the storage-tank tap gave no indications of injurious pollution.

F. H. FINLEY & SON.

[Massachusetts avenue and Second street NE.]

This firm manufactures a variety of carbonated and soda waters and a distilled water for table use. The establishment is a fair-sized one and well kept. The basis for all its products is said to be distilled tap water, which is filtered before being distilled.

The distilled water flows from the patent condenser into enamel-lined tanks. The bottles used for distilled water are washed in warm alkaline tap water, rinsed, and then filled at a tap connected directly with the above-mentioned enamel-lined tanks. The half-gallon bottles are stoppered with a porcelain stopper, those of larger size with new corks wrapped in tin foil.

A bottled sample (No. 458) obtained at the bottling establishment showed, chemically, no evidence of pollution; but bacteriologically showed some contamination in the handling, but not of an injurious character.

GITCHE CRYSTAL SPRING WATER.

[Geo. N. Beebe, 1729 Florida avenue.]

This water is one of the most extensively used in the city. It is obtained from a spring near Bennings, D. C. The spring appears on the slope of a wooded, uninhabited hill, where it is completely covered over and sealed and from which the water is piped to a small wooden galvanized iron-lined tank in a shack at the base of the hill. The tank holds about 1,000 gallons and serves the purpose of a reservoir. From this reservoir it is pumped into wooden paraffin-lined tanks, in which the water is hauled to the city and delivered to the consumer at his door.

The delivery tank is provided with a manhole, closed with a tin cover, which is not air-tight, so that as the water is drawn the street air, more or less dust-laden, enters. The interior is cleansed and reparaffined from time to time.

Chemical and bacteriological examination of a sample (No. 357) taken from the waste pipe leading from the tank showed no evidence of pollution.

RED OAK SPRING COMPANY.

[Office, Eleventh and F streets NE.]

This company bottles and sells for table use a water obtained from a spring about 1½ miles out on the Bladensburg road, District of Columbia.

The spring appears at the base of a knoll which is under cultivation and on which is a house now untenanted and said to have been unoccupied for some months. About 150 feet away is a barn not in use at the time of the inspection. Adjoining the barn was a box privy, but this has been moved some 300 feet below the spring and to the far side of a little brook which flows by. The natural drainage from the barn is toward the brook. The present location of the privy removes it from all consideration in connection with the spring. Such drainage from the slope as would tend toward the spring is diverted to either side by a shallow furrow plowed across part of the slope above the spring. Careful provision has been made for the protection of the spring and the water. The spring itself has been surrounded in a radius of 8 feet by a thick circular concrete wall extending, it is said, about 15 feet below the ground surface, and on it a substantial spring house has been erected. This is kept closed against intruders. The floor of this spring house is vitrified brick laid in cement, and in the center is sunk a glazed terra-cotta cylinder about 3 feet in diameter, into which the spring wells up and from which the water is piped a distance of about 15 feet to a concrete basin serving as a reservoir and protected by a house similar to the spring house. The waste flows off into a catch basin, from which it runs through a pipe to the brook. The water is pumped from this reservoir into 5-gallon glass carboys and hauled to the office, where it is poured into glazed earthenware crocks in preparation for bottling. The bottling is done in a large airy room adjoining the office proper. Here the bottles and carboys are cleaned, first in tap water, then in hot spring water, and drained. The bottles are then filled from the crocks, the water flowing out through a faucet into a funnel covered with a cloth intended to act as a straining cloth. This cloth is washed from time to time. Half-gallon bottles are stoppered with a porcelain stopper having a rubber gasket, both of which are first washed in the spring water. The 5-gallon carboys, after being filled, are cork stoppered.

A sample (No. 371) taken from the waste pipe at the spring was examined chemically and bacteriologically. Considering all the evidence, this water may properly be regarded as unpolluted.

E. A. BUTTS.

[734 Fourteenth street NW.]

This firm sells Geneva Red Cross lithia and Hume Spring water, both of which are bottled on the premises.

Bottling.—The bottling is said to be done in a little room partitioned off from the rear portion of the store. At the time of the first visit inspection was denied on the ground of its being in use for some other undefined purpose, but after an hour admission was permitted. This interval was probably used for preparing the place for inspection. In this little room the bottles and carboys are said to be cleaned with sand and tap water and then filled by pouring directly from the carboys through a funnel or first into an enameled ware tub and then dipped from this and poured through the funnel. After filling, the bottles are cork stoppered.

Hume Spring water.—This water is hauled from the Hume Spring in 5-gallon carboys. This spring is on the Hume property about 5 miles from the Aqueduct Bridge in the direction of Alexandria, Va. The spring originally appeared in a little gully, but this was filled in some years ago to about 7 feet on all sides of the spring, so that now it is in the center of a circular depressed space about 15 feet in diameter and about 10 feet deep. The floor about the spring is well paved and the circular wall is brick lined. A flight of stone steps leads down from the level above the floor. Over all this is a circular roof supported on columns about 15 feet high.

The water rises in a glazed terra-cotta pipe, which is moss-grown, and overflows at one point and runs off in a little trough. An auxiliary spring, which is completely sealed from view, discharges by a small iron pipe into the same little trough which carries away the overflow from the main spring. The spring, though private property, is open to the public. The surrounding land is under cultivation, and about 500 feet away is a barn.

A sample (No. 437) taken from the main spring was chemically and bacteriologically examined. Considering all the evidence this water may properly be regarded as unpolluted.

CASTALIA SPRING WATER.

This is bottled at the spring and so brought to the city. The spring is about 3 miles from Branchville, Md. It rises at the base of a low wooded hill with no habitation very near. It is inclosed by a quadrangular concrete wall sunk several feet below the surrounding level and inclosed and roofed over by a low wooden structure.

Bottling.—The bottles are stored and cleaned in a small adjacent wooden house used only for this. The cleaning is done in a tub by hand, using warm spring water for the purpose. Before filling they are rinsed with clean, fresh spring water. The filling is done by permitting the water to flow directly into the bottle from the spring through an iron spout. They are then stoppered with new corks. Bacteriological and chemical examination of a sample (No. 447) taken at the spring gives no evidence of pollution.

CRYSTAL ROCK WATER COMPANY.

[Manager, 1212 H street NW.]

This company sells water obtained from a well in Virginia, the property of W. B. Matthews, about 2 miles from the Chain Bridge.

Well.—The well is on a hill close to a dwelling. There is a privy and barn about 150 feet away, the drainage from which is in a direction away from the well. The well is said to be about 60 feet deep and is sealed with a galvanized iron cover over which is laid a wood floor.

Bottling.—The bottles are cleaned in the well water and then filled through funnels. The water is strained through a cloth tied over the spout.

The bottles thus filled are hauled to the city and distributed from the storeroom at 1212 H street NW.

Examination of a sample (No. 438) taken at the well after a few minutes of pumping gave no evidence of injurious pollution.

ARLINGTON BOTTLING COMPANY.

[Twenty-seventh and K streets NW.]

This is a large bottling establishment which puts on the market a variety of carbonated waters, among which may be mentioned "Sparkling Rock Spring Lithia," "Blue Label Wiesbadner Sprudel," and "Arlington Spring Mineral Water."

LABEL.

Sparkling
Rock Spring Lithia
Cool before using.
Recommended by physicians for its
purity and healthfulness.
Rock Spring Lithia.
Chas. Jacobsen, Sole Distributor.
Washington, D. C.

LABEL.

Blue Label Wiesbadner Sprudel.
Sprudel Wiesbadner Wasser.
Keep cool and on its side.
Kühl und liegend aufzubewahren.
Friedrichs Quelle,
Natural Mineral Water.
Caution
The corks of the genuine bear the brand
"Friedrichs Q."

LABEL.

Arlington Springs.
Keep in a cool place and laid on its side.
Arlington Springs Mineral Water.
A. B. Co.
Trade mark
Bottled by the
Arlington Bottling Co.
Chas. Jacobsen, Proprietor.
Washington, D. C.

These names and the labels on the bottles are misleading as to the character of the contents. They are all filtered tap water to which salts are added and then artificially carbonated.

Samples were taken of the filtered tap water (No. 384), and bottles of the "Sparkling Rock Spring Lithia" (No. 461), "Arlington Spring Mineral Water" (No. 462), and "Sprudel Wiesbadner Wasser" (No. 463) were obtained at the bottling establishment and submitted to bacteriological and chemical examination. None of these showed indications of injurious pollution.

NORWOOD ARTESIAN WATER COMPANY.

[1804 H street NW.]

This company bottles and sells water filtered through a Berkefeld filter from a so-called artesian well.

Well.—The well is on the premises of Dr. Ralph Walsh, on Norwood Heights. It is about 75 feet from the nearest dwelling, and about 200 feet distant from it is a privy and somewhat nearer a barn. The surface drainage from the barn and privy is away from the well. The well is said to be about 200 feet deep. The water is pumped into a 3,000-gallon tank, from which it is drawn daily into barrels and carboys in the quantity needed and hauled to 1804 H street. Here, in a clean, airy cellar, the water, after being pumped from the barrel or carboy and forced through a Berkefeld filter, is bottled.

Bottling.—The bottles are cleaned with tap water and sand and rinsed with the filtered well water, with which they are filled directly as it flows through a rubber tube from the Berkefeld filter.

Half-gallon bottles are stoppered with porcelain stoppers, which are provided with rubber gaskets, all of which are washed in the filtered water before using. The larger carboys are cork stoppered.

Samples were taken at the city depot of the raw unfiltered water (Nos. 409 and 466) and of the water immediately after it had been forced through the Berkefeld filter (Nos. 410, 467, and 468). Chemical and bacteriological examination gave evidence of pollution in this water; considering all the circumstances this is probably due to the method of handling.

MAGNESIA CRYSTAL TABLE WATER.

[Office and springs, 117 Anacostia road, District of Columbia.]

The label on bottles of this water is misleading in that it is intended to create the impression that it is a spring water, whereas it is pumped from a well, bottled, and sold.

LABEL.

Magnesia Crystal Table Water
The purest and healthiest
of table waters.
Office and springs:
117 Anacostia Road, D. C.
Wm. B. Young,
Manager.

Well.—The well is at the rear entrance of the dwelling at 117 Anacostia road. The well is said to be lined with brick which are laid in cement above the level of the water. It is covered by a board platform, the seams of which are caulked. About 25 feet from the pump is a box privy, the drainage from which is in a direction away from the well.

Bottling.—The bottles are washed in the well water, sand being used when thought necessary. The bottles are filled by pumping directly into them and are then cork stoppered. Returned corks are washed and used over again.

Chemical and bacteriological examination of samples (Nos. 394 and 456) taken at the well gives evidence of sewage pollution.

This water has been on the market only two or three months.

PURE TABLE WATER.

[Home Ice Company, Twelfth and V streets NW.]

This water comes from a bored well 60 feet deep on the premises of the Home Ice Company. The water is forced up by air pressure and piped to an enamel-lined tank, from which the bottles in which it is sold are filled.

Bottling.—The bottles are washed by hand in the well water and are then filled through a funnel from a tap connected with the enamel-lined tank. In the filling the water is strained through some cheese cloth in order to exclude sand grains and other foreign particles. This water has been on the market about two months.

A specimen (No. 238) of this water gave no evidence of recent pollution by either bacteriological or chemical examination.

TAKOMA SPRING WATER.

[F. W. Bougley, Takoma Park.]

This water is from Takoma Spring.

Spring.—The opening is near the base of a wooded hillside at Takoma Park. It is arched over by a brick and masonry structure having a door which is sealed. The water is piped to a nearby spring house where the bottling is done. Most of the water is wasted by flowing from the spring through a terra cotta pipe.

Bottling.—The bottles are cleaned in the spring water and are said to be filled from the tap in the spring house. Half-gallon bottles are stoppered with porcelain stoppers, the larger with corks.

Bacteriological and chemical examination of a sample (No. 420) taken at the spring gave no evidence of pollution.

MAGNOLIA SPA WATER.

[Magnolia Spa Water Company, Lanham, Md.]

This water is from a spring about 1½ miles from Lanham, Md.

Spring.—It is one of several which rise at the base of a low hill on the top of which is a dwelling. The spring is inclosed in a pipe of terra cotta and this is surrounded by masonry, which is roofed over by a wooden cover and closed by a wooden door. A further attempt is made to keep the surface drainage from the slope from reaching the spring by a masonry wall extending across the slope above the springs. The water flows from the spring through a galvanized-iron pipe.

Bottling.—The bottles are cleaned by hand in the spring water to which an alkali is said to be added to aid in the cleansing process. The bottles are filled through a funnel by simply allowing the water to flow in from the mouth of the pipe. The water is strained through a cloth to remove foreign particles. The bottles are cork stoppered, the corks being washed before using.

A sample (No. 421) taken at the spring showed no evidence of pollution on chemical and bacteriological examination.

SAMUEL C. PALMER.

[1066-1068 Thirty-second street NW.]

This firm puts out a variety of "soft drinks," including a brand called "Allegheny Mineral Water." This "Allegheny Mineral Water" is simply tap water filtered, carbonated, and bottled.

The bottles are washed in alkalin tap water, rinsed in fresh tap water, and then filled at a bottling machine.

Bacteriological examination of a sample of the filtered tap water (No. 400) and of the charged (Allegheny Mineral Water) water

(No. 465), taken in sterile bottles, and of the bottled water (Allegheny Mineral Water) in the original container (No. 464) shows evidence of contamination in handling.

THE RENAL SPRING WATER.

[H. Gerhold, Eleventh street and Park road.]

This water, which from its name one would suppose to be a spring water, is in fact derived from a well said to be 60 feet deep. The well is in a wooden shack about 15 feet from a barn. The interior of the well is brick lined and it is covered by some wooden planking.

The bottling is done in an adjoining shack. The water is pumped into buckets, from which it is dipped out and poured into bottles through a tin funnel, being strained in the process through a piece of cloth to remove any coarse particles. The bottles are washed before filling in well water to which some soda is said to be added. Only new corks are said to be used for stoppering.

LABEL.

The Renal Spring Water.

U. S. and D. C. analyses.

Recommended by doctors and health authorities.

Result of analysis is as follows:

Bicarbonate of soda	0.148
Bicarbonate of calcium	.596
Bicarbonate of magnesia	.786
Chloride of sodium	1.100
Sulphate of sodium	1.176
Iron and alumina	.206
Silica	.638
	4.65

Office: Park Road and 11th St. Ex'd.

J. D. Hird. A. M., Chemist.

Keep in a dry place.

A sample (No. 472) of the water taken at the well gives no evidence of bacterial pollution; but chemical examination gives indications of probable seepage from the nearby barn.

POLAND WATER.

This table water is brought to the city bottled and is sold in these original containers.

A sample (No. 471) purchased from a dealer gives no evidence of pollution.

Table showing results of chemical and bacteriological examinations of table waters vended in Washington, D. C

[Examinations under direction of chiefs of divisions of Bacteriology and Chemistry.]

Laboratory No.	Legend.	Chemical (parts per 1,000,000). Total solids. Total residue.	Total solids. Mineral matter.	Total solids. Volatile matter.	Free ammonia.	Albuminoid ammonia.	Nitrites.	Nitrates.	Chlorin.	Bacteriological. Number of bacteria per cubic centimeter.	Minimal fermentation in lactose bouillon.	B. coli in.
											cc.	*cc.*
238	Pure table water	280	184	96	0.008	0.020	0.0001	5.0	4.35	60		
357	Gitche Crystal Spring water	16	12	4	.016	.028	None.	.05	2.4	14		
371	Red Oak Spring water	98	28	70	.018	.148	.0004	2.0	7.6	1		
384	Arlington filtered water	144	98	46	.048	.036	None.	.75	3.3	8		
394	Magnesia Crystal table water	94	64	30	.020	.072	.0186	5.0	8.6	288	1	10
400	Samuel C. Palmer (filtered tap water)									3		
401										(a)		
409	Norwood artesian water (unfiltered)	210	80	130	.024	.028	.0100	7.5	16.5	250	10	10
410	Norwood artesian water (filtered)									5,000	10	10
420	Takoma Spring water	28	20	8	.016	None.	.0018	.6	4.8	2		
421	Magnolia Spa water	12	2	10	.003	.028	.0013	.04	1.9	58		
429	Powhatan Spring water	30	10	20	.016	None.	.0010	.40	3.3	30		
437	Hume Spring water	100	86	14	.028	.004	.0063	.01	2.4	7		
438	Crystal Rock table water	44	26	18	None.	.008	.0037	.03	2.1	44		
447	Castalia Spring water	36	10	26	.068	.016	.0012	.375	3.4	41		
456	Magnesia Crystal table water									286		
457	Great Bear Spring water	160	130	30	None.	.058	.0006	1.25	2.4	82	1	
458	F. H. Finley & Son's distilled water	16	10	6	None.	None.	.0007	.06	Trace.	1,720		
461	Sparkling Rock Spring lithia	1,546	1,442	94			Trace.	.5	566	1,830		
462	Arlington Springs mineral water	1,198	1,114	84			Trace.	.4	440	68		
463	Sprudel Wiesbadner Wasser	1,278	1,180	98			.0001	.4	460	92		
464	Allegheny mineral water									51	10	

a Innumerable.

Table showing results of chemical and bacteriological examination of table waters vended in Washington, D. C.—Continued.

Laboratory No.	Legend.	Chemical (parts per 1,000,000).								Bacteriological.		
		Total solids.										
		Total residue.	Mineral matter.	Volatile matter.	Free ammonia.	Albuminoid ammonia.	Nitrites.	Nitrates.	Chlorids.	Number of bacteria per cubic centimeter.	Minimal fermentation in lactose bouillon.	B. coli in.
											cc.	*cc.*
465	Allegheny mineral water									14	10	
466	Norwood artesian water (unfiltered)									(*a*)	1	1
467	Norwood artesian water (filtered)									754		
468	....do									708		
470	M. L. Harper's distilled water	40	32	8	0.024	None.	0.0714	0.05	Trace.	1,065	10	
471	Poland water	108	88	20	.024	0.028	Trace.	1.2	5.2	1,440		
472	Renal Spring water	194	78	116	.072	.012	.0137	9.0	33	184		

a Innumerable.

VI.—TYPHOID "BACILLUS CARRIERS."

TYPHOID "BACILLUS-CARRIERS."

By Joseph Goldberger,
Passed Assistant Surgeon, Public Health and Marine-Hospital Service.

The great importance of contact, direct and indirect, in the epidemiology of typhoid fever has been receiving increasing attention in recent years. One of the most interesting and important facts developed as a result of this relates to the part played in the transmission of the disease by persons apparently in perfect health.

The fact that persons in average health might harbor the cholera vibrio in their intestinal tracts or the diphtheria bacillus in their throats has been known, and its importance in prophylaxis appreciated for some years; but it is only a few years since the suspicion, that a similar relationship might exist in the case of man and the typhoid bacillus, has actually been confirmed.

It has been found that persons apparently well may discharge typhoid bacilli in the urine or feces for months and even years after passing through an attack of the disease. It has been known since 1881 that typhoid bacilli may be present in the urine during an attack of typhoid fever, but the knowledge of their persistence therein long into convalescence and even for years after is comparatively very recent. In 1899 a remarkable case was reported by Richardson. The patient, a man, returned to the Johns Hopkins Hospital five years after having been treated there for typhoid fever. Investigation showed him to be suffering from a cystitis, and the typhoid bacillus was obtained in pure culture from his urine.

Büsing (1902) reported finding the bacillus in the urine of a trooper returned from China four months after an attack of typhoid. This man, except for a slight tendency to frequent micturition, presented no symptoms that would attract attention to his condition.

Liebetrau (1906) has reported a very interesting and instructive case. On and off since 1896 there had occurred cases of typhoid fever in newcomers to a mill in the town of W——. A fatal case in a servant in October, 1905, caused an investigation to be made, which led to the discovery that the brother of the mistress of the place, a man who had lived at the mill a great many years, and who

had had a severe attack of typhoid in 1896 was discharging typhoid bacilli in his urine and feces in almost pure culture.

In the feces of those who have had typhoid fever the bacillus has been found to persist for even longer periods than in the urine, and such persons may continue to endanger the public health for many years.

Kayser (1906), in investigating a small milk outbreak (5 cases) in Strassburg, traced the infected milk to a small dairy where was discovered a chronic bacillus carrier in the person of a 12-year old lad in whose stools typhoid bacilli were present in large numbers. This lad had had an unrecognized attack of typhoid six months before.

This writer, in the same paper, mentions another milk outbreak (17 cases) which was also traced to a dairy, where there was found a chronic bacillus-carrier in the person of a woman in whose feces the bacilli were present.

In another paper Kayser (1906) reports the case of a chronic bacillus-carrier which well illustrates the dangerous character of such persons. This one, a woman 40 years old, had had an attack of typhoid when she was about 10 years old, subsequent to which she suffered from jaundice, and for five years preceding the date of coming under observation had been suffering from attacks of gall-stone colic (it will be remembered that her attack of typhoid dated back thirty years). Fecal examination November 24, 1904, and repeatedly since, has shown the persistent presence of the typhoid bacillus. Her blood, tested January 11, 1905, gave a positive agglutination with typhoid bacilli in a dilution of 1:1,000. In 1904 two cases of typhoid fever occurred in members of her household in which no other source of infection could be found. Two other cases occurred in neighbors with whom she had business dealings.

Lentz (1905) mentions a case in which the organisms were present in the feces forty-two years after an attack of typhoid.

Of perhaps greater interest and not less importance is a group of persons who have been found to discharge typhoid bacilli in urine or feces for long periods, but have never experienced any clinical manifestations of the disease. Most, if not all, of the individuals belonging to this group have at some time been in a more or less close association with persons actually sick with the disease.

The literature contains some interesting and instructive illustrations.

Houston, in 1899, reported a case of cystitis of three years standing in which the typhoid bacillus was found in the urine in pure culture. The patient, a woman, had lived in the house where two children whom she had helped to nurse had died, one of bronchitis

and the other, she thought, of diarrhea, shortly before the onset of her symptoms.

Drigalski and Conradi (1902) isolated the typhoid bacillus from the stools of four persons who showed no symptoms of any kind, but who had been in close contact with cases of typhoid fever.

Dönitz (1903) mentions two cases of typhoid fever in children who were probably infected by their mother, who, though apparently well, had typhoid bacilli in the urine. She had probably acquired the infection from a case of the disease which had occurred on the premises four months before.

Liebetrau (1906) reports the case of a woman, an attendant in a prison, who was found discharging bacilli in the feces two years after having nursed two cases of the disease. She was well and had never been sick. The occurrence of 4 cases of typhoid in inmates, who had been there so long that they could not have acquired their infection outside, led to her discovery and isolation, after which no more cases appeared.

No exact estimate of the frequency of chronic typhoid bacillus carriers can be made at this time, the literature on the subject being as yet too scanty. A working idea, however, may be formed.

The frequency with which the typhoid bacillus has been isolated from the urine varies widely, as may be seen from the table. This variation depends, in part, on differences in technique and, in part, on the stage of the disease in which the studies were made and the frequency with which the examinations were repeated in each case. Considering only the studies (indicated in the table by a *) made on cases taken at random, since the introduction of the serum agglutination test for the identification of the bacillus, and averaging the results, it would appear that the typhoid bacillus occurs in the urine in about 16 per cent of cases.

At the typhoid observation station at Idar, Lentz (1905) found that 4 per cent of all cases observed became chronic typhoid bacillus carriers. He gives in tabulated form the results obtained at the other typhoid observation stations, which show quite a marked variation. Averaging the results obtained by Lentz (1905), Klinger (1906), and von Drigalski (1906), we find that of 1782 cases of typhoid fever 53, or about 3 per cent, became chronic carriers.

An explanation of the long existence of the typhoid bacillus in the stools is to be found, at times, in chronic typhoid ulcerations, but more commonly in the infection of the gall bladder with this bacillus.

Nieter and Liefman (1906) report a case which is of interest in this connection. In the course of an investigation of the cause of the persistent occurrence of cases of dysentery and typhoid fever in a certain insane asylum they found amongst others a case of chronic

dysentery from whose discharges they isolated the typhoid bacillus. Shortly after this she died, and at necropsy there was found, besides a chronic catarrh of the lower intestine, many typical old typhoid ulcerations in the small intestine. The gall bladder was full of small and large gall stones and the typhoid bacillus was found not only in the small intestine but in pure culture in the gall bladder.

The typhoid bacillus enters the gall bladder from the blood. In the gall bladder it finds the bile a satisfactory medium in which to live and multiply, which it may do for years, and with which it is discharged in variable numbers into the small intestine. In the gall bladder it may give rise, as in the case above cited, to gall-stone formation and to cholecystitis of varying degrees of intensity.

Several interesting and valuable contributions on this phase of the subject have been made, among which may here be mentioned those of Blachstein (1891), Welch (1891), Dupré (1891), Gilbert and Girode (1893), von Dungern (1897), Cushing (1898), Miller (1898), Droba (1899), Hunner (1899), Brion (1901), Blumenthal (1904), Forster and Kayser (1905), Doerr (1906), and Spartaco Minelli (1906).

The long persistence of the typhoid bacillus in the urine is usually associated with more or less marked cystitis, as in the cases reported by Blumer (1895), Houston (1899), and Büsing (1902). The bacilli may find their way into the urinary bladder, as Kurth (1901) suggests, by wandering from the anus to the meatus urinarius, especially in women, or perhaps by penetrating the recto-vesical septum, as suggested by Blumer (1895); but during the febrile period of the disease they most commonly pass from the blood through the kidneys. In the bladder they multiply and are usually found in enormous numbers in the voided urine.

It may be of interest to cite from the literature a few additional instances illustrating the dangerous character of bacillus-carriers.

Walker (1900) reports the case of a yeoman returned from South Africa after an attack of typhoid who, by infecting a well, caused 12 cases of the disease.

Allbutt (1901) reports an exceedingly interesting and instructive observation: A convalescent from typhoid went from Liverpool to visit a kinsman on a distant and isolated farm. Shortly after his arrival a servant was taken sick. Several weeks after recovering from her attack this woman went to serve at another place at some distance from the first. Some weeks later a case of typhoid developed on the latter farm.

Dönitz (1903) mentions the case of a woman who was discharged from the hospital recovered from an attack of typhoid in November. In the following June her husband developed the disease, and examination showed the wife to be discharging the typhoid bacillus in her urine.

He mentions another instance in which one girl probably contracted the infection from another with whom she shared her bed; her companion was found to have the bacilli in her urine.

Friedel (1906) gives an account of a series of outbreaks of typhoid in an insane asylum which he traced to an imbecile helper in the kitchen of the institution. In all, 63 cases were produced by this woman who had been in the asylum six years, and had not been known to have had the disease, but who was found with the bacilli in her feces.

He speaks also of a woman who, during the first six weeks of her convalescence from an unrecognized attack of typhoid, caused 11 cases of the disease in members of her family. At the end of this time she was found to be discharging the bacilli in her urine.

Liebetrau (1906) reports the case of a woman, K ——, who had typhoid from January 17 to the end of February, 1905. Fecal examination as late as October, 1905, showed her to be still discharging typhoid bacilli. In April, 1905, the woman K —— went to live at the house of O ——, where she remained till July 10. Two members of the family of O —— were taken sick in June, and a third about a month after K —— left the house. The last case was probably infected by contact with one of the former cases. The woman K ——, therefore, may be regarded as having caused, in all, three cases of the disease within a comparatively short period.

More instances could be cited; but it is believed that the above will sufficiently indicate the serious menace which typhoid bacillus carriers are to the public health.

Table showing frequency of typhoid bacilluria.

Date.	Reported by—	Number cases studied.	Number cases B. typhosus present.	Percentage cases B. typhosus present.
1881	Bouchard	65	21	32.00
1886	Seitz	7	2	28.00
1886	Hueppe	18	1	6.00
1887	Chantemesse and Widal	2	0	.00
1887	Berlioz	14	2	14.00
1888	Neumann	25	6	26.00
1888	Konjajeff	20	3	15.00
1890	Neumann	48	11	23.00
1890	Karlinski	44	21	48.00
1892	Silvestrini	7	7	100.00
1892	Stenbeck	2	2	100.00
1892	Enriquez	12	7	60.00
1892	Poniklo	1	1	100.00
1894	Borges	10	1	10.00
1895	Baart de la Faille	27	4	15.00
1895	Wright and Semple	7	6	85.00
1897	Horton-Smith*	7	3	43.00
1897	Besson	33	6	18.00
1897	Levy and Gissler*	22	10	45.00
1898	Petruschky*	50	3	6.00
1898	Richardson*	38	9	24.00
1899	Richardson*	66	14	21.00
1899	Horton-Smith*	12	4	33.00
1899	Schichold*	17	5	29.00
1900	Horton-Smith*	39	11	28.00
1900	Neufeld*	12	3	25.00
1901	Cole*	49	17	35.00
1901	Kurth*	45	5	11.00
1901	Hayaschikawa*	9	5	55.00
1901	Schuder*	22	5	23.00
1901	Vincent*	46	9	20.00
1901	Lewis*	45	1	2.00
1902	Bliss	311	31	10.00
1902	Fuchs*	41	4	10.00
1902	Jacobi*	35	7	20.00
1903	Lesieur*	15	7	47.00
1904	Herbert*	98	18	18.00
1904	Stefanelli and Cumbo*	21	7	33.00
1905	Fornaca and Meille*	19	8	41.00
1906	Vas*	26	6	23.00
1906	Olbrich*	10	3	30.00
1906	Brown*	15	8	53.00
1906	Brion and Kayser*	48	12	25.00
1906	Drigalski*	546	32	6.00
		2,004	348	17.39

* Denotes studies of cases taken at random since the introduction of agglutination test.

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VII.—THE LONGEVITY OF B. TYPHOSUS OUTSIDE OF THE HUMAN BODY.

THE LONGEVITY OF B. TYPHOSUS OUTSIDE OF THE HUMAN BODY.

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The important question in relation to this subject is, "Can the bacillus remain viable and virulent outside of the human body and under natural conditions long enough to transmit the infection from man to man by means other than by direct contact?" This is easily answered positively, but the subquestions of how long, and in what media, and under what conditions it may do so, are not so simple of solution.

Much evidence is adduced to throw light upon these questions from epidemiological observations and deductions, but in the following discussion only such of this evidence as is supported by bacteriological demonstration will be presented. Purely bacteriological experiments, on the other hand, are of value only when the conditions at least approximate the natural, and the greatest weight should be given those which do so, and at the same time conform to the strictest scientific methods. Unfortunately such cases will be found to be comparatively rare in the literature of the subject. An ideal experiment of this nature involves the following three principal steps: (1) Maintaining the chosen medium (water, soil, food, etc.) inoculated with B. typhosus under conditions simulating the natural, (2) isolating with certainty any typhoid-like organism from the medium after exposure, and (3) identifying the organism isolated as surely B. typhosus, including, if possible, a quantitative estimation.

Most of the work reported fails in one or more of these steps. Failure in step 1 gives obviously misleading results. In step 2 the failure to isolate the bacillus, if present, gives a shorter longevity than really obtains. The failure to completely identify the organism in step 3 invalidates the entire experiment. In the present state of bacteriology, step 3 can be completely controlled by specific cross-agglutination and Pfeiffer's reaction, but step 2 unfortunately still fails of satisfactory technical methods.

To show how complex experimental investigation along these lines becomes, and in explanation of the diverse results of different observers, some of the influences to be reckoned with are given:

1. The medium itself: As to its chemical, bacterial, and protozoan content, qualitative and quantitative. The amount of medium used also has a bearing upon the results.

2. The container: As to its effect on the contained medium in influencing its temperature, chemical composition, etc. Vessels of certain kinds of glass affect the chemical nature of contained fluids.

3. Exposure: (1) To light, whether sunlight, diffuse or artificial light; (2) to heat of various degrees; (3) to air or other gases; (4) to moisture, and (5) to shaking or motion. Fluctuations or intermittence of exposure are also important.

4. The bacteria used for inoculation: (1) As to the strain used, whether recently isolated or not; (2) the number added relatively to the bulk of medium used, and (3) the amount of nutrient material added at the same time, intentionally or otherwise.

5. The methods of isolation and identification used.

6. The method of recording results.

7. The personal equation of the experimenter.

We have no original work to report on the longevity of B. typhosus, but have attempted to ascertain what results of value have been obtained by others. The classical articles referred to in text-books and compilations too often turn out on examination to be quite valueless from the standpoint of to-day.

Longevity in water.—Many of the earlier investigators of this subject used sterilized water in order to avoid the difficulties of subsequent isolation. Practically, no one cares what the viability in sterile water may be, as this is not found in nature in civilized regions. Many others, not only of the early, but also of recent experimenters either employed inadequate methods or failed to report their technic, so that their results must be thrown out if reliable conclusions are to be reached.

It might be mentioned here that quite enough instances of the isolation of B. typhosus from naturally infected waters are at hand to prove bacteriologically its occurrence therein. They seldom throw much light upon the length of time that it may remain there viable. The following case, reported by Kübler and Neufeld (1899), is of great importance in this connection. In 1898 they isolated B. typhosus from a well which had been infected by washings from the chamber used by a typhoid patient. The organism was identified culturally and by specific agglutination and Pfeiffer's reaction. One-fifth öse was pathogenic to a 300 gm. guinea pig intraperitoneally injected. Four weeks later they again isolated a similar organism from the same well, lacking only the pathogenic property for guinea pigs. They were able to exclude reinfection of the well during the meantime, as the dejecta were carefully disinfected for three weeks before the first specimen was taken, and thereafter. Critically examined, however, the possibility of washings from the polluted ground having entered the well in the time between the examinations could not be excluded, and we can only assume from this case that in that often-occurring natural combination of earth and water

the bacillus may remain viable at least four weeks under natural conditions.

A somewhat similar case is reported by Stroezner (1905), who isolated B. typhosus from a well four or five weeks after the falling sick of the third and last case in the house supplied by it. During the sickness of this last case the dejecta were disinfected. Identification of the organism was complete. The possibility of continued infection from the soil applies equally as much as in the previous case.

Tavel (1903) cites a case where apparently the water of a public supply became infected in the pipes, from negative pressure caused by the varying level of the system, and remained infective for several months in a stagnant terminal. In a single house supplied by a private pipe arising 50 cm. from the end of this terminal, typhoid cases recurred long after the epidemic in the town had subsided. The town epidemic occurred in the latter half of October, and no cases occurred there subsequently. In the house mentioned, however, cases kept occurring, the first on October 30, and then as follows; December 7 and 9, March 16, and April 4, 8, and 29. On April 30 the blind terminal was exposed and opened, and a specimen of the slimy water was sent to the laboratory, where the typhoid organism was found in it a few days later. Identification of the organism was complete. In this very important contribution no definite period of longevity is arrived at, but the evidence is very strong that the water of this terminal remained infected for about five months. The fact that no subsequent cases appeared in the town would seem to exclude continued infection at the original site. The house was located at the lower part of the town, where negative pressure and reinfection from that source did not occur. It must be admitted, however, that contact infection is competent to explain the persistence of typhoid in this house.

Approaching the question from a purely experimental side, Konradi (1904), working in 1901, obtained most remarkable results, which differ radically from those of most observers. His methods are not given in his report. He states that under certain conditions the pathogenic organisms outgrow the saprophytes in water. In tap water inoculated with typhoid spleen the typhoid bacillus was still living after four hundred and ninety-nine days at room temperature and five hundred and forty-two days at body temperature. When typhoid culture was added to the water, the figures were four hundred and ninety and four hundred and twenty days, respectively. In the absence of any account of the methods employed, little weight can be given to these results. Fehrs explains this extraordinary longevity by the fact or supposition that considerable nutrient material was added at the same time with the bacteria, as it certainly must have been when spleen pulp was used for inoculation.

Pfuhl (1902) found the bacillus alive after twenty-six days in

unsterilized tap water at the temperature of wells, 7°–10°, using 100 cc. specimens in glass vessels. He could not find it after thirty-one days or later.

Hoffmann (1905) gives interesting results of experiments in aquarium water. The aquarium contained 30 liters of tap water and was inhabited by snails, fish, and water plants. The bacterial count of the water before inoculation was 60,000 per cubic centimeter. Enough bouillon culture was added to give 300,000 typhoid bacilli per cubic centimeter immediately after inoculation. The aquarium was so placed as to be exposed to direct sunlight for some hours daily. B. typhosus could be recovered after thirty-six days from the water, and after two months from the mud. His methods were good. This experiment is of value in teaching that the action of protozoans in destroying typhoid bacillus is less to be counted on than the experiments of Huntemüller (1905) and Fehrs (1906) would indicate. These investigators did not make use of special methods for the isolation of the bacillus as Hoffmann did. Hoffmann found many protozoans present in the water of his aquarium, but if they were responsible for the disappearance of B. typhosus, their action was much too slow for sanitary purposes. Another point of value is the longer viability in the mud than in the water itself. Fehrs does not attempt to ascertain the absolute longevity of B. typhosus, but shows that the addition of protozoa to boiled water inoculated with B. typhosus reduces the viability from forty-six to sixty days, to thirteen to nineteen days.

Jordan, Russell, and Zeit (1904) attempted to simulate the natural conditions by suspending permeable sacs containing water inoculated with B typhosus in natural bodies of water. These sacs were supposed to be impermeable to bacteria themselves but to permit the exchange of their dialyzable products. The methods of isolation and identification employed were of the most modern description. They concluded that competing organisms in the water soon outgrew the specific bacterium, especially in polluted waters and sewage. In Lake Michigan water the bacillus was recovered only up to seven days; in Chicago River water, heavily polluted, three days; in the drainage canal on the first and second, and in one instance on the tenth day; in the Illinois River, three days. Russell and Fuller (1906) employing similar methods arrived at corresponding results, recovering the bacillus from Lake Mendota water after ten to thirteen days, during which the temperature varied between 9° and 23° C. In sewage, at 21°–29°, the organism lived but three to five days. They also made experiments which tended to show that the destruction of the organism depends more on the coincident growth of the other bacteria than on the influence of dialyzable products. While these investigations represent a praiseworthy attempt to copy natural conditions, there seems to be some doubt of their success in this direction, inasmuch as in the series of Jordan, Russell, and Zeit

some of the experiments were made in ordinary glass containers, and gave admittedly parallel results to those made with permeable sacs. Again, Johnson (1905) states that in the case of B. coli he has demonstrated the possibility of the escape of the organism through the walls of the sac without impairment of its dialyzing power. He argues a similar or more active escape of the more motile B. typhosus, and contrasts the results of Frost (1904) with those just now cited.

A fact of importance in the case of water epidemics is that carbonated waters, bottled waters, and "soft drinks" made from the infected water are as dangerous as the water itself, or more so, because they would be taken with less caution by the uninformed. Pfuhl (1902) found B. typhosus in artificially infected seltzer water after twenty-seven days when it was kept at a temperature of 7° to 10°.

For the benefit of those who wish to draw deductions from experiments made with sterilized water under laboratory conditions and with methods of varying excellence, the following summary of the results is inserted. As they give but a fragmentary view of what were in some instances extended observations, the original sources must be examined for particulars.

TABLE I.

Author.	Date.	Medium.	Temperature.			Other circumstances.	Found.	Not found.
			Low.	Medium.	High.			
			°	°	°		*Days.*	*Days.*
Bolton	1886	Distilled water		20			14	
				35			2-3	
Wheeler	1906	do	10-12			Dark	17	
				20		do	37	
				22		Light	13	
					37	Dark	15	
		Sterilized tap water.	10-12			do	21	
				20		do	43	
				22		Light	15	
					37	Dark	17	
		Sterilized well water.	10-12			do	37	
				20		do	79	
				22		Light	15	
					37	Dark	17	
Wolfhugel and Riedel	1886	Sterilized water		18-22			32	
Bobrow	1893	Sterilized spring water.		14-18			25	28
			1-2				9	10
Cassedebat	1890	Sterilized water		(?)			44	
Braem	1889	do		(?)			60	188
Frankland	1895	Steam sterilized water.	Summer and winter.			Various waters.	17-75	
Wood	1896	Sterilized sea water.	4	20			[a]6	

[a] Months.

Viability in feces, soil, cadavers, etc. Some of the work already reviewed gives instances where part of the time reported as the observed period of longevity in water must be attributed to soil. Levy and Kayser (1903) report an instance of natural occurrence where water, excepting the moisture of rain, etc., played no part. The stools of a typhoid patient were placed in a cemented vault between September 8 and 13, 1901. As the patient was then removed to another locality for treatment, it is presumed that no further typhoid infection of the vault occurred. The contents of the vault were removed and placed on garden earth as manure on February 6, 1902. When this became known to the local physician, he took specimens of the soil on which the feces had lain, on February 20, and sent them to the laboratory, where B. typhosus was recovered from them. No doubt of its identity exists, as it agglutinated with specific serum in a dilution of 1–5,000. This, it will be noticed, was in winter, and the temperature of the soil in the vicinity varied from 0° to 4.2° C., and that of the atmosphere from $-5.4°$ to $+11.6°$ C. Before we accept the results of this case without reserve, reinfection of the soil or feces after February 6 must be absolutely excluded, a manifest impossibility, but aside from this imperfection the case is proof of the existence of B. typhosus in feces and soil for at least five months.

Robertson (1898) experimented with soils out of doors and under natural conditions, except as regards inoculation, which was with bouillon culture and at various depths, after the removal of the grass. In one series he was able to recover the organism after one hundred and forty-three days, but could not do so a week later. The period covered was from May to October. In another series he tried to recover it after about three months, but failed. However, by enriching the soil from time to time with weak beef tea or other organic matter he succeeded in reviving the bacillus and isolated it from the same soil after nearly a year (eleven months). This process of organic enrichment is paralleled where the soil around a sink drain is continually moistened by seepage, or where kitchen waste is thrown out on the ground. His method of isolation did not include enrichment processes, but identification was complete, so that the error, if any, was in the direction of shortening the period of viability. He also states that the bacilli inoculated at a depth of 18 inches grew to the surface, but that no lateral growth could be demonstrated. He shows also that sunlight has only a superficial effect, as the bacillus was found at a depth of only one-sixteenth inch in some cases. In a later report he expresses the opinion that the bacillus dies out in the superficial layers of the soil during the winter but that the deeper layers remain able to reinfect the surface with the advent of warm weather. He states also that the bacillus dies out quickly in grass-covered surfaces.

Firth and Horrocks (1902) worked with blocks of earth cut from

natural fields, gardens, etc., and placed on a veranda exposed to cold and light. In some instances the samples were moistened with rain water proportionately to the precipitation at the time. Their experiments were very numerous and can not be given here in full, but the following are some of their important findings. Inoculating the soil with an emulsion of typhoid bacilli free from nutrient material, and keeping it moist with rain water, they were able to recover the bacillus up to the sixty-seventh day, and up to the fifty-fifth day even when the ground had been frozen part of the time and the average temperature was 9° C. Using sterile dilute sewage for moistening, this period was increased to seventy-four days at an average temperature of 17.7° C. Using the soil from around a drain inoculated with the emulsion as before and moistened with raw sewage (free from B. typhosus), the organism was recovered after sixty-five days, although the ground had been frozen for several days. In soil fouled by sewage and kept from air and light the bacillus lived forty-five and fifty-three days, respectively, in different experiments, freezing having occurred during the former. In peat kept moist, the bacillus lived only ten or eleven days, in fine sand kept moist only thirteen days. In dried soils the bacillus did not persist as long as in moist, but lived twenty-five days after the completion of the drying to such consistency as to be blown about as dust. Under the influence of flooding the bacillus penetrated the intact earth to a depth of 18 inches but not of 2 feet. The soil was closely packed. To determine the influence of sunshine, infected soil was exposed to this agent and the bacillus isolated from it after twenty days, during which it had received direct sunshine for one hundred and twenty-two hours. Only the superficial layers were examined.

Pfuhl (1902) succeeded in demonstrating a viability of 88 days in moist earth at a temperature of 1.5° to 15° C. In dry sand, however, it lived but twenty-eight days.

Martin (1899–1900) found a shorter period of viability, but his methods of isolation were not very searching. He apparently reports finding it after fifty days on one occasion in moist or flooded soil, but repudiates this finding in a subsequent report. Where very little moisture was present and the temperature varied from 2° to 12° C., it was found after twelve days, but was absent after twenty days. The same observer was able to isolate it from sterilized soil after four hundred and fifty-six days.

Klein (1898–99) attempted to determine the longevity of B. typhosus in buried cadavers, using guinea pigs killed by intraperitoneal injections of typhoid cultures. On exhumation, the washings of the peritoneum were examined for the bacillus. In animals buried in sand, he was unable to find the organism after fourteen days, although he

found it at that time in one buried in ordinary earth. He could not find it at all after twenty days.

Loesner (1896), however, working with the bodies of swine, found the bacillus after ninety-six days in one case. In this instance the spleen of a typhoid patient was placed in the cadaver, and this wrapped in cloth and inclosed in a wooden box was buried 1.5 meters deep in sandy loam. Winter conditions prevailed during the experiment. Loesner noted no tendency to infect the surrounding soil.

Gartner (1898) found that B. typhosus could live in loosely packed manure for ten days at a low temperature, 3–5° C., but disappeared more quickly at higher temperatures and in closely packed manure.

Concerning the possibility of B. typhosus living in dried earth capable of being blown about as dust much has been written, Germano (1897) deducing from his experiments that conveyance by these means is unlikely. His methods, however, do not bear strict scrutiny, and the work of Firth and Horrocks above referred to shows the possibility of such a means of transmission.

Harrison and Harrison (1904), in India, under conditions which would seem especially inimical to B. typhosus and using, as they observe, rather inadequate methods of isolation, showed that in absolutely dry dust exposed to diffuse light the bacillus lived one hundred and eighteen hours. Exposed to sunlight it lived seventy-seven hours, during which time it was exposed to direct sunlight for twenty-three hours. The dust was sterilized to avoid difficulty in isolating the organism, but, as the authors state, in an absolutely dry condition competitive organisms could have but little influence. They conclude that in India, at least, the dust is a possible and likely medium of transfer of typhoid fever.

Concerning the infection of growing vegetables by polluted soil, Wurtz and Bourges (1901) have demonstrated by the following methods that it may occur. Pots of earth were planted with the seeds of cress, lettuce, and radishes, and the earth sprinkled with water containing B. typhosus. The tips of the resulting plants' leaves were then examined from time to time and the bacillus constantly found up to three weeks after inoculation of the soil.

Some of the results with sterilized media are appended, with the observation that they do not pretend to reflect natural conditions.

TABLE II.

Author.	Date.	Medium.	Temperature.	Found.
			°	*Days.*
Dempster	1894	Dry soil [a]		9-14
		Moist soil [a]		23–42
Karlinski	1891	Sterilized earth	18	[b]3
Uffelmann	1894	Sterilized garden earth	Room.	21
		Sterilized white sand		82
Rullmann	1901	Sterilized earth and various organic substances.		[b] 5–16
		Sterilized mortar sand		[b]12
		Sterilized dried earth		[b]18
Martin	1899 1900	Moist soil	3–37	456
		Dry soil		([c])
Horrocks	1899	Sterilized sewage	16–22	5
		Sterilized sewage+B. coli		60

[a] Various soils. [b] Months. [c] Short time.

Viability in shellfish and sea water.—While the unmistakable tracing of many cases of typhoid infection to the eating of shellfish has called forth much laboratory investigation, very little of the reported work can be accepted without doubts, as either the methods were manifestly unreliable or there was an unfortunate failure to state what procedures were employed. Foote (1895) examined oysters and found no bacteria present which could be confused with the typhoid bacillus. He consequently assumed that anything isolated subsequent to inoculation with B. typhosus and corresponding culturally must be that organism. Oysters were inoculated between their shells by means of a syringe and kept at 50°–65° F., in a heap. An organism corresponding culturally to B. typhosus was isolated from the shell juice after twenty-eight days, from the stomach after eight days but not after twelve days. Sea water taken from an oyster bed and kept in liter flasks still contained the organism ten days after inoculation, when observation was terminated by the breaking of the containers through the freezing of their contents. Kept at room temperature in sea water it could be recovered after seventeen days, not after twenty-one. Of course the imperfect technic impairs the value of these experiments. Wood (1896) attacked the question by adding to sterilized sea water such organisms occurring in sea water as could not be mistaken for the typhoid. He then added B. typhosus, and, keeping the water at a temperature varying from 4° to 20° C., recovered the bacillus after three months. It is interesting as evidencing the lack of influence of the salts of sea water upon this organism that it was recoverable from sterilized sea water after at least six months.

The positive results reported by Field (1903–4) are of some value, as his identification of the organism isolated was complete, while the negative findings can not be given much weight, as no special means were employed to recover the B. typhosus. His results for oysters allowed to remain in infected sea water showed a viability of nine days in shell water and a negative result in fourteen days; for oysters placed in new sea water after infection, forty-eight hours, not longer; for sea water itself six to eight days. Wood and Klein unfortunately omit a description of their methods in such reports as we have been able to consult, but Wood (1896) gives a viability in unsterilized sea water of three months at various temperatures from 4° to 20° C. Klein (1905) reported that infected oysters kept in sea water constantly changed retained the bacillus six to seven days as a rule; kept dry, eleven days. Other shell fish retained it much longer.

Viability in dairy products.—The work of Bruck (1903) is of great interest in this connection. This observer followed in all his experiments conditions which obtain in the ordinary handling of dairy products. He took ordinary milk from the dealers and infected it with B. typhosus. He then separated the cream in the centrifugal machine commonly used for that purpose and found that it contained the organism not only immediately after separation but continued to do so for ten days. Others have shown that centrifugation of milk does not precipitate all of the bacteria to the slime layer, but allows many to remain in the cream—more, even, than in the skim milk. (Bassenge.) From another portion of this cream he manufactured butter, from which he could still obtain B. typhosus up to the twenty-seventh day, but not on the twenty-eighth or later. The buttermilk retained the bacillus only ten days. There even appeared to be some growth of the organism in butter for the first few days. He then demonstrated that by rinsing the churn with infected water the butter made therein could be infected, a fact which would hardly seem to call for proof. His methods throughout appear to be of the best.

Pfuhl (1902) after inoculating unsterilized milk found that the bacillus was demonstrable after thirteen days, but does not state when negative results were obtained. In butter it lived twenty-four but not twenty-six days, and for Gervais cheese the same figures are given.

Concerning the viability in milk, raw and sterilized, much might be adduced, but it is well known that milk is ordinarily used long before any typhoid bacilli present would have died out.

The limiting influence appears, according to Bassenge (1903) to be the acidity, which is fatal to the bacillus within twenty-four hours after reaching 0.3 to 0.4 per cent.

Little detailed material is at hand concerning other kinds of food, but Hesse (1889) working with sterilized food-stuffs found that 21 out of 30 were good media for the development of typhoid bacilli.

Viability on fabrics, clothing, etc.—Parkes (1903) cites a case of natural occurrence controlled bacteriologically, which shows that B. typhosus may remain viable and virulent on blankets for six months. These blankets, last used in military service in South Africa, were sold under emergency without having been cleaned, and some of them found their way to the training ship *Cornwall* in the Thames. An outbreak of typhoid occurring on the ship, some of the blankets from the lot received from South Africa were sent to Klein for bacteriological examination, and he found the B. typhosus to be present. The period of time from the use of these blankets to the finding of the bacillus was about six months. Firth and Horrocks (1902) give the following results of their observations upon fabrics. On khaki inoculated with an emulsion of typhoid bacilli, dried and kept at an average temperature of 54° F., the organism lived seventy-four days. On khaki and blue serge similarly treated it lived eighty-seven days. On khaki drill infected with liquid stools and kept at an average temperature of 61° F. it lived only seventeen days, and when dry stools were used for inoculation it lived but nine days. Pfuhl (1902) says that dried on linen it lived ninety-seven days, while Billings and Peckham (1895) state that dried on threads and kept dry in vacuo it was still living after two hundred and seven days and kept over sulphuric acid after two hundred and thirteen days.

Insects.—The agency of insects in transmitting typhoid is well known from epidemiological observations, and this is also demonstrable bacteriologically, at least for flies. Firth and Horrocks have shown that flies may carry the bacillus and infect media, and give evidence that the external parts and not the excreta harbor it. Hamilton (1903) captured flies which had visited typhoid dejecta in a sewer traversing an infected neighborhood and demonstrated that they carried the bacillus. Ficker (1902–3) attempted to determine how long the bacillus could live on flies infected from blotting paper soaked in bouillon culture, and found that it could survive for at least twenty-three days. Howard (1900) states that he found 77 species of diptera on feces, of which number 36 bred therein. He also states that the house fly does breed in human feces, although preferring horse dung for that purpose.

The following list of references to articles having more or less bearing upon the longevity of *B. typhosus* is appended for the use of those who wish to consult the original sources. Articles referred to in the foregoing résumé are indicated by an asterisk.

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VIII.—THE ALLEGED ROLE OF INTESTINAL WORMS AS INOCULATING AGENTS IN TYPHOID FEVER.

THE ALLEGED ROLE OF INTESTINAL WORMS AS INOCULATING AGENTS IN TYPHOID FEVER.

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SUMMARY.

According to a theory recently advanced in France intestinal worms (especially whipworms) form the inoculating agent in typhoid much in the same way that fleas inoculate bubonic plague. The theory is based upon the high percentage of whipworms reported for typhoid cases by some authors and upon the fact that intestinal worms may wound the mucosa; it is assumed that the uninjured mucosa forms an impassible barrier to the bacteria which, however, may pass through these wounds. The theory claims that typhoid bacilli in the intestines are harmless unless parasitic worms, or some other wounding agents, are present. Accordingly, the treatment and prevention of typhoid reduces itself essentially to treatment and prevention of parasitic worms, especially of whipworms. The theory is extended to appendicitis, cholera, and certain other intestinal diseases.

More recently, the theory is also extended to include parasitic protozoa as inoculating agents in intestinal diseases, but so far as typhoid is concerned no definite statistical data are presented in support of this extension. As the fresh, warm, stools should be examined to test this phase of the subject fairly, and as conditions were not favorable for such examination in the present instance, this protozoan phase of the subject could not be consistently studied in the present report.

The Washington epidemic of typhoid in the summer of 1906 presented the possibility of putting to a practical test the verminous side of this exceedingly alluring theory. The results of the study have failed to confirm the theory, for 92.5 per cent of the patients showed no infection with intestinal worms, while only 15 of them (7.5 per cent) showed a total of 16 infections (8 infections per hundred) of which 14 cases (7 per cent) showed whipworm infection. This represents an increase of only 1.3 infections (0.65 infection per hundred persons) over what we expected to find in the general intestinal helminthiasis, and an increase of only 1.32 per cent over what we expected to find in whipworm infections. Considering the very wet season we have had, and especially in view of the negative findings in 92.5 per cent of the patients, these slight increases can hardly be considered of importance.

In comparing the severity of the verminous infections (as judged by the number of eggs present) with that reported for typhoid by Guiart in France, it was found that the

[a] In making the 2,000 microscopic examinations involved in preparing this paper, I have been aided by Passed Asst. Surg. Joseph Goldberger, David G. Willets, Ph. B., and Arthur E. Paterson, Ph. B.

Washington cases averaged only 0.47+ whipworm egg per slide, against 2 eggs per slide in the French statistics.

Turning to a method of indirect comparison, it is seen that while former examinations in this laboratory (for Washington, D. C., and for Connecticut) showed that the greatest percentage (13.01) of cases of whipworm infections was under 15 years of age, in the 200 typhoid cases examined the greatest percentage (47.5) of patients fell between the ages of 15 and 29 years, inclusive; further, the percentage of cases of typhoid does not vary parallel with the percentage of cases of whipworm infection in the other age groups.

Comparing, in reference to sexes, the statistics of whipworm infection in the world at large, and in examinations made for Connecticut and for the District of Columbia combined, with those of the 200 typhoid patients examined, it is seen that whipworms are more common in females than in males, while of our 200 typhoid cases, 52.5 per cent were males and 47.5 per cent were females. If the comparison is restricted to the total helminthiasis of cases examined in the District of Columbia, it is slightly more favorable to the theory under discussion.

Making a similar comparison in reference to the race of patients, it is seen that in the 200 cases of typhoid under discussion (reduced to figures approximately in harmony with the general relation of the races in the population of the District) the whites were to the negroes as 55.5 to 64, while in the whipworm statistics in former examinations the whites were to the negroes as 3.75 to 9.79. The change in our summer population would account for at least a part of this excess of typhoid among the negroes.

The general conclusions are, therefore, that a study of the intestinal helminthiasis in 200 of the cases in the Washington typhoid epidemic of 1906 has not supported the theory that whipworms, eelworms, or other species of intestinal worm bear any necessary or common relation as an inoculating agent in typhoid fever; and that the view recently expressed in France to the effect that the treatment and prevention of typhoid fever practically reduces itself to the treatment and prevention of intestinal worms, especially of whipworms, does not obtain, at least so far as this locality (Washington, D. C.) is concerned. The question of the relation of protozoa as inoculating agents in typhoid is not considered in this report.

INTRODUCTION.

From time to time, in medical and helminthological literature, authors have called attention to the frequency of infection with intestinal worms found in cases of typhoid fever. These observations have recently culminated in a theory to the effect that whipworms (*Trichuris trichiura*) play an inoculating rôle in typhoid somewhat similar to that played by fleas in bubonic plague.

This theory is in itself a very alluring one. If it is substantiated, its effects are of far-reaching importance. Not only would it mean that the prevention and treatment of typhoid would practically resolve itself into the prevention and treatment of whipworms, but a practical application of the prophylactic measures might involve more or less of a revolution in the present methods of the disposal of sewage. On this account it seems wise to test the theory from different points of view and in different geographic areas, lest a study of the subject from one point of view or in a limited geographic area may, because of local conditions, lead to erroneous conclusions.

The outbreak of typhoid fever in Washington, D. C., during the summer months of 1906, has given me an opportunity to test the theory in this locality and to compare my results with results published for France and Italy. In this study I have had a certain advantage over my European colleagues, for not only have I had a larger number of cases for comparison, but in analyzing the cases it has been possible to draw a comparison between two races of patients, whites and negroes.

In order to understand the points at issue, it will be well to quote extensively from certain European authors, especially from Guiart, the chief exponent of the theory involved.

As will be seen from the extracts, typhoid is not the only disease which comes up for consideration. I have not, however, had an opportunity to study the other maladies (appendicitis,[a] cholera, etc.) from the point of view of intestinal helminthiasis.

As will be seen also from the extracts, the theory in question may be summarized as follows: There are certain pathogenic bacteria which do no harm in the lumen of the intestine; but if parasitic worms (especially whipworms or eelworms) happen to be present, these parasites wound the mucosa of the intestine, and the bacteria gain access to the system through the wounds; thus clinical typhoid is dependent upon the presence of a wounded mucosa, and as the whipworm represents the most common intestinal worm, this is usually the inoculating agent of typhoid. This I believe is a fair statement of the theory.

In considering the subject it would seem logical to expect that, if the theory be correct, not only must we find that practically all typhoid patients harbor intestinal worms (especially whipworms), but we can go further, namely, since we know that one sex (female) in man presents a higher intestinal helminthiasis than does the other, also that whipworms and eelworms are more common in persons of certain age groups (under 15 years) than at other ages, and finally that whipworms especially are more common in the negro than in the white, we may naturally expect, in accordance with the theory, that in any given locality the cases of typhoid will be correspondingly more common in the sex (female), at the ages (under 15 years) and in the race (negro) presenting the highest percentage of intestinal helminthiasis in question.

There are several articles (Metchnikoff, 1901; Matignon, 1901a, 1901b; etc.) in recent medical literature on the presence of worms in the appendix or on their relation to appendicitis. They are

[a] Through the kindness of Dr. George Tully Vaughan and Dr. D. Percy Hickling, of this city, I have been able to examine several cases of appendicitis for intestinal worms. While the results were negative, the statistics are not extensive enough to justify any generalizations.

not reviewed in this paper, as typhoid fever is the question especially at issue. From cases reported in literature it seems difficult to exclude parasitic worms as *at least occasional* factors in appendicitis. Metchnikoff's advice to make fecal examinations in all cases can do no harm and may do good. It seems rather early to generalize on this subject, either positively or negatively.

HISTORICAL REVIEW.

Turning now to the arguments and views presented in favor of the theory, we may note the following:

Guiart (1899a, 1000–1002) says:

It is probable that all of the epidemics of verminous fever of former times were in reality only epidemics of ascariasis of typhoid form, or perhaps of typhoid fever accompanied by helminthiasis. But Davaine did not sufficiently explain the association of the infection and of ascarids, and in a recent work an Italian author, Demateis (1899a), shows that certain of the interpretations of Davaine ought not to be accepted to-day and that the ascarids are not simple foreign bodies contained in the intestines, but that they are endowed with very energetic movements, which become accentuated under the influence of an elevation of febrile temperature, and that they are able to become very dangerous for the host who harbors them. We accept fully this opinion, adding that not only is the fever able to provoke the pathogenic action of the ascarid, but this latter by its presence alone is able to provoke the fever by giving rise to alterations in the intestine which are able to serve as ports of entry to the infection.

Certain authors have indicated that at the points where the ascarids attach it is not rare to observe a slight softening of the intestinal mucosa and a fine vascular injection similar to that of erethematous enteritis. Leroux has shown further, in an intestine containing 83 ascarids, small points, having the appearance of punctures, surrounded by a small red circle. Finally, in cases of ascariasis of the dog, Friedberger and Frœhner also report, at the plane of the tumefied and catarrhal mucosa, numerous small rounded blackish points, at the center of which is an ulcerative depression surrounded by a salient zone. But Davaine does not admit that these lesions can be due to the action of the ascarid, because the jaws [lips] of the parasite would not be able, according to him, to act on an object situated in front of them, but only on an object introduced into the buccal orifice. This opinion has not been accepted so positively by everyone, and I have recently had [1001] occasion to observe a fact which permits me to be more affirmative.

In the cruise of the *Hirondelle*, in 1888, the Prince of Monaco captured, near the Azores, a dolphin, the stomach of which contained a very great number of *Ascaris conocephalus* Krabbe, which were given to me awhile ago to determine. Certain of these parasites were affixed to the mucosa, and the cephalic button, profoundly incrusted in the tissues, was covered with a sort of rather deep cupula, presenting asperities sufficient to permit the worm to fix itself solidly with its teeth. * * * This cupula is a veritable mold of the cephalic extremity of the ascaris, and it is deep enough so that the mucosa is seriously wounded at this point. These lesions are certainly identical with those observed by Leroux in man and by Friedberger and Frœhner in the dog. But the cephalic armature of *Ascaris conocephalus* is absolutely similar to that of *Ascaris lumbricoides* of man. It is, then, very probable that what one makes the other is also able to make, and we are consequently in the right in admitting that *Ascaris* is perfectly capable of cutting the intestinal, or at least the stomachal, mucosa.

If now we consider well that the parasite lives in the midst of the intestinal material—that is, in a septic medium—we understand that the ulceration produced by the bite of the parasite will easily be able to become inflamed and to result in an abscess, or even to give rise to various enterites, for instance, under the action of *Bacterium coli*, or of the typhoid bacillus. We now understand then better the coincidence, so striking sometimes, of typhoid fever and [1002] of *Ascaris*, and that all the better because the etiology [source of infection] is in reality the same, and for the two should be sought in the impurity of the drinking water. In cases of enteritis of typhoid form one ought, then, especially in cases of doubtful bacteriologic diagnosis, to make a microscopic examination of the fecal material, and if one finds *Ascaris* eggs one ought to administer santonine.

In another paper Guiart (1900f, 70–81, fig. 1) gives a brief historical review of certain epidemics in which *Ascaris lumbricoides* was reported as common. He elaborates slightly on his earlier (1899a) paper, and refers to the possibility of *Ascaris* as an inoculating agent in typhoid.

Guiart (1901a, 307–308) in a later paper says:

This week M. Metchnikoff has just presented to the Academy of Medicine [Paris] a very interesting communication and one which has made considerable stir in the medical world, because it concerned appendicitis. * * * I am very glad, so far as I am concerned, to see that Metchnikoff confirms the ideas which I myself have advanced here, a little over a year ago, on the rôle of *Ascaris* as an inoculating agent in intestinal affections. *Our two communications constitute in reality two specific cases of a general law: That of the action of intestinal worms as inoculating agents of certain intestinal affections.*[a]

I do not wish to return here to what I have said apropos of the rôle of *Ascaris* and what has just been confirmed by Metchnikoff. But in regard to the whipworm, it is now three years that, in my lectures on parasitology before the medical school, I have insisted on its frequency in the cecum and on *the important rôle which it ought to play in the inflammatory maladies of this region; in fact, it fixes itself in the mucosa by its thin extremity and thus becomes an inoculating agent of the first order.*[a] About eighteen months ago, I gave this question to M. Brumpt, preparateur of Professor Blanchard's laboratory, to study during his "passage" [term?] in the hospitals. Only once did he encounter whipworms in the appendix; but in the necropsies on typhoid cadavers he very frequently found whipworms *attached* in the superficial portion of the mucosa of the cecum. M. Brumpt has not yet published his observations, and as he is at present traveling in Central Africa, I have thought it well to speak of them here.

I hope that I shall not be interpreted as saying that I consider the whipworm as the cause of typhoid fever;[a] that would be as much of an exaggeration as to interpret Metchnikoff as saying that this worm is the specific cause of appendicitis. *Its true rôle is as follows: Our intestine harbors a very rich bacterial flora and many pathogenic bacteria are found there; but fortunately, in the normal state, the intestinal epithelium offers to them an insuperable barrier. It is in reality, like our external skin, always soiled with bacteria; but it does not let the bacteria penetrate except in case of a cut or a wound. Thus, in the intestine, the pathogenic bacteria remain without action, if the mucosa is not abraded by a foreign body or by a solid particle ingested with the food, or is not injured by some worm living in its lumen. In fact, this worm, fixing itself on the mucosa in order not to be removed by the fecal material, wounds the mucosa and the conditions change; the bacteria, inoculated by the parasite, develop under the mucosa, and will produce, according to the case, an enteritis, an appendicitis, a simple abscess, or even a peritonitis. Since, in our*

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[a] Italics not in the original.

country, the typhoid bacillus is one of the most abundant, the result is that the intestinal parasites open especially the door to typhoid fever; but in other countries they produce inoculation with dysentery and with cholera.[a]

I thus think that the whipworm acts simply in the same way as any intestinal worm; and as it constitutes with *Ascaris* one of the most frequent parasites of the intestine, the result is that one ought with right to reckon with it, all the more because it is to-day demonstrated that it really fixes itself in the mucosa by its cephalic extremity, as results from some observations by Railliet and Brumpt. I believe that the whipworm is able to act eventually in the etiology of appendicitis; but that is indeed rather rare (see below, p. 202). In fact, if whipworms are rather common in the cecum, one must admit that they are encountered very rarely in the appendix. Thus, of 174 appendices excised surgically and examined in the laboratory of practical pathology by Doctor Letulle and Doctor Weinberg, only 2, one of which was brought to me, contained whipworms.[b] If it is probable that whipworms may play a rôle in certain cases of appendicitis, I believe at least that its rôle is much more active in other intestinal affections, and particularly in enteritis.

To summarize: *The helminths and the bacteria of the intestine are inoffensive in themselves, but the helminths are capable of becoming inoculating agents of the bacteria, in the same way as the mosquito does in malaria, or, better, in yellow fever.*[c][d] The helminths may thus play a very important and generally unrecognized rôle in the etiology of intestinal affections, and this forms one of the most interesting cases of parasitic association. I am also persuaded that the day physicians begin to make systematic microscopic examinations of the fecal matter for eggs of parasites, they will be astonished at the rapid progress which will result in our knowledge relative to the etiology and treatment of parasitic diseases of the intestine and liver.

The following abstract of a paper (1902 [e]), by Rostortzeff (1902, 692), is taken from the Medical News:

In the course of his extensive anatomical studies of the topography and pathological anatomy of the appendix, Doctor Rostortzeff came to the conclusion that Metchnikoff's opinion on the causative influence of worms on appendicitis can hardly be accepted. On the one hand, he found the parasites in a comparatively small percentage of the examined appendices, and, on the other, of those appendices where he found the parasites a great many were perfectly normal.

Blanchard (1904, Dec. 1, 122–128) presented to the French Academie de Médecine a general review of Guiart's work, based upon a paper prepared by Guiart. The paper is practically a summary of Guiart's former publications on the relation of whipworms to typhoid.

Blanchard (1904, Dec. 1, 138–140; 1905, 50–51), in discussing the general subject, says:

From a strictly medical point of view, the helminths are about to retake in medicine a rôle which was formerly attributed to them without question, but from which the progress in bacteriology has deposed them. The discovery of the pathogenic rôle of the microbes has been the origin of surprising progress in etiology, prophylaxis, and treatment of the infectious diseases. By a very comprehensible exaggeration, people

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[a] Italics not in the original.

[b] The whipworm was fixed through the superficial portion of the mucosa.

[c] Italics not in original.

[d] Guiart should not be misconstrued here as suggesting that the worms act as *intermediate hosts* in the life cycle of the bacteria.

[e] The original is not accessible to me.

have wished to attribute everything to the microbes, and this was a singular solace for medicine, to find at last in them the explanation of pathogenic phenomena which, since centuries, obstinately refused to deliver up their secret. *Far be it from me to contest the capital rôle which these infinitely small organisms play in the production of diseases, but I am clearly of the opinion that often they are not harmful except because they are preceded in their nefarious work by various parasitic worms which open for them the way and permit them to exercise their evil work.*[a]

Guiart has recognized that *Ascaris conocephalus* produces in the intestinal mucosa of the dolphin rather profound erosions, thanks to the three powerful nodules with which its mouth is armed; *Ascaris lumbricoides* acts proportionately the same in man. And indeed clinicians have often noticed, without attaching to this fact the importance which it merits, the existence of more or less numerous ascarids in individuals suffering from intestinal affections, especially from typhoid fever. Rœderer and Wagler in 1760 observed at Gœttingen a severe [51] epidemic of typhoid fever, or of *morbus mucosus*, as they said, in the course of which they discovered the whipworm; this parasite was found in abundance in the intestine of persons on whom they were able to make an autopsy. We are not ignorant that at a very recent epoch Professor Metchnikoff has recognized that this same helminth was the frequent but not exclusive cause of appendicitis.

Does this mean that the helminths are infectious? Not at all; their pathogenic rôle is indubitable, but in a way it is only preparatory. The ascarid, we have seen, erodes and ulcerates the intestinal mucosa; the ravages experienced by the latter are still more grave when it is attacked by whipworms, hookworms, and other helminths which, armed or not with hooks, pierce through it and sink into its interior down to contact with the blood capillaries. There is thus produced a series of very minute openings, through which the pathogenic microbes, which are so frequently found as saprophytes in the intestine of persons in good health, are able to invade the organism and cause the infection. *One might therefore proclaim this aphorism: No intestinal infection without parasitic worms to open up the way for the infectious microbes.*[a]

Niclot (1905, Jan. 15, 322–323) reports two cases of typhoid in which whipworms were found.

Spezia (1905, Oct. 16, 460) found whipworm eggs in 17 out of 19 cases of typhoid cases in Italy; the preparations averaged 3 eggs to a slide. In view of these results, compared with examinations he made in other diseases, Spezia is led to agree with Guiart regarding the importance of whipworms in typhoid.

Vivaldi & Tonello (1905, 1362–1363; 1906, 136) examined the stools of 50 typhoid cases in Italy, and found that 80 per cent. showed whipworm infection; in 50 cases of other diseases they found 42 per cent. whipworm infection and 25 healthy persons presented 32 per cent. whipworm infection; the infections in the typhoid cases were 3 to 4 times as great as those in the other cases. The typhoid patients also presented 11 *Ascaris*, 4 *Oxyuris*, and 2 hookworm infections.

Guiart & Grimbert (1906a, 557–567), in discussing the relations of intestinal worms to the human economy, say that the worms may act—

3. By inoculating in the mucosa of the intestinal tract pathogenic bacteria which are able to exist in the contents of the intestine. Thus the intestinal worms play a

[a] Italics not in the original.

considerable rôle in the etiology of diseases of the intestine and of the liver in the same way that insects do in the etiology of infections of the blood. They act especially as inoculating lancets, and according to the virulence of the microbic species of the intestine, one finds himself naturally in the presence of affections of variable gravity. *If, in fact, the inoculated agent is slightly pathogenic, it is sufficient to expel the intestinal worms in order to see the symptoms decrease and disappear;*[a] that is the triumph of anthelminthic medication. *If, on the contrary, the microbes inoculated in the mucosa have a true specificity, the disease continues its evolution, even after the evacuation of the parasites; but at least one prevents constant auto-inoculation and one is able to prevent the infection from becoming chronic.*[a] These are facts of a more general application, applicable as well to comparative pathology and to human pathology. It is thus that Professor Moussu has shown the action of the strongyle of sheep in the inoculation of bovine pasteurellosis. We completely adopt his conclusions, and we protest against the present views which consider as inoffensive the parasites which are able to inoculate fatal infections. *These infections are bacterial, it is true, but they would not occur if the parasites did not exist.* [558] *It is thus the latter which are in reality the more important agent.*[a] * * *

[559] We are going to attempt to show that what the ectoparasites (mosquitoes, etc.) are capable of doing on the surface of our body, the endoparasites are capable of doing in our intestine.

One admits at present that a simple puncture of a needle is able to open the door to pathogenic bacteria, that the bite of a flea is able to inoculate plague, that of the mosquito malaria, filariasis, and yellow fever. How, then, is one able to admit that a parasite is able to produce lesions of the intestinal mucosa and is able to open with impunity the blood vessels without ever opening the door to infection? But the content of the digestive tube does not pass exactly for an aseptic medium. The most abundant microbe of the fecal material being the colon bacillus, it is this which will be most often inoculated, and thus can be explained certain enterites of the child or of the adult, general or partial, and among these appendicitis.

[560] In France there was a general laughter when Metchnikoff claimed that appendicitis could be produced by intestinal worms; to-day, still, one sees the smile of pity on the part of medical students when in examination they are questioned in regard to the rôle and diagnosis of the intestinal worms in appendicitis. The opponents of the theory base their position on the fact that appendices are removed daily without finding the slightest intestinal worm. As if the worm had to penetrate into the appendix in order to produce appendicitis! The surgeon is not surprised, however, that a small wound on the foot results in an inguinal adenitis. The skin and the intestine are two tissues of the same origin: why refuse to one what is admitted for the other? It seems to us logical to admit that a parasite fixing itself in the intestine can inoculate at this point, into the mucosa, pyogenic bacteria which are transported by the lymphatics in the neighboring lymphoid tissue, and as this lymphoid tissue is especially abundant in the appendix, the bacteria inoculated in the region of the cecum are very naturally going to result in an inflammation of the appendix. It is thus that all intestinal worms able to live in and attach themselves to the cecum are able to be a cause of appendicitis. These will nearly always be ascarides or whipworms. Further, since Metchnikoff's communication, and despite the detractors, the facts have multiplied singularly. It is permitted to think that in a little while the intestinal worms will be considered not only as the cause of some rare cases of appendicitis, but perhaps as the most frequent etiologic factor. One of us (Guiart) has had occasion to observe five cases of appendicitis in persons around him. In the first case an acute appendicitis was definitely cured after the spontaneous expulsion of an ascarid. In the four other cases the fecal material was sent to him for examination for the presence of intestinal worms. Not

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[a] Italics not in the original.

having found anything in two cases he advised operation. But in the other two cases, having found the eggs of ascaris in one case and [561] the eggs of whipworms in the other, he ordered santonine for the former and thymol for the latter. [a] The cases of appendicitis ceased as if by enchantment, and since then have not reappeared. One of these cases occurred three years ago, the other one year ago. * * *

We are persuaded that all of the cases of familial and of recurrent appendicitis are amenable to anthelmintic medication. [b] We believe even that one should have recourse to this medication before every operation. In fact, in one of the foregoing cases, which was operated because of negative results in the fecal examination, the young patient passed a male ascaris the day after the operation. Later doses of santonine were without effect, but the presence of this single male ascaris permits us to explain at the same time the appendicitis and the lack of eggs.

What has just been said of appendicitis can be extended also to *typhoid fever.* Whether one considers this affection as produced by the bacillus of Eberth or by the cobacillus, one scarcely explains how the bacillus is able to pass the barrier, which the intestinal epithelium offers to it, in order to implant itself in the mucosa. Further, *if the bacillus acted alone, one would not understand why, in a population drinking the same contaminated water,* [c] *so few people are in reality affected. On the other hand, if one admits that the inoculation occurs by the intermediary of intestinal parasites, the facts are very easily explained.* [b] One understands very well the so striking coincidence of typhoid fever with ascarids and whipworms. We ought not to be astonished if the cases were numerous in which anthelminthics acted favorably in these affections; they acted, without doubt, by preventing the auto-inoculation of the malady.

Such is the theory advanced by one of us (Guiart) in 1901, treated again in 1902, and again in 1904, in a report presented [562] to the French Colonial Congress. Finding himself at Brest during the months of August and September of the same year, at the beginning of an epidemic of typhoid, he resolved to try to verify his hypothesis.

Permitted to examine the patients under treatment at the hospital, *he examined the fecal material of 12 typhoids and in 10 of them he found constantly the eggs of whipworms.* [b] It sufficed to make 3 microscopic preparations [in each case]. He was thus able to find from 1 to 21 eggs in the 3 slides, and for all an average of 2 eggs per slide. When one recalls that in verminous appendicitis it is often necessary to make a dozen preparations before finding an egg of a parasite, and that each microscopic preparation necessitates an extremely small amount of fecal matter, one understands that to find so easily the eggs of whipworms in the typhoids, it is necessary that the adult worms be particularly abundant in the intestine.

There remain the two patients in whom he did not find the whipworm eggs. One of these, dying, 6 living whipworms were found in the cecum. [b] *Was there an interruption in the oviposition or were they only male worms?* [b] These are the two probable hypotheses which could not be verified, however, as he (Guiart) was not present at the autopsy. There remains a last negative case, which did not come to autopsy, but which perhaps finds its explanation in the foregoing.

The parasite, at Paris at least, is never so frequent or abundant; it was important to know whether it showed the same frequency in the other soldiers under treatment at the hospital. Guiart examined the fecal matter of 4 individuals. [b] * * * In the first 3 he did not find a single egg, despite many preparations. In the other he found 1 egg [563] in 6 slides, a low proportion when one considers that the typhoids presented an average of

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[a] In view of the difficulty encountered in expelling whipworms from the intestine, Guiart's interpretation of this case is not altogether convincing, especially since he gives no record to show that the whipworms were actually expelled.—C. W. S.

[b] Italics not in the original.

[c] It will be noted that Guiart looks upon the water as the chief source of typhoid fever, see above, p. 119.

7 eggs in 3 preparations—that is, an average fourteen times as high. The existence of this egg in the patient with an amputation would explain, perhaps, an attack of dysenterie nostras from which he had formerly suffered.

It was thus demonstrated that numerous whipworms existed in the intestines of typhoids, although these same worms are rare and not very abundant in healthy persons or in persons with nonintestinal affections.[a]

From new observations made at Paris, it results that whipworms abound in the intestine of typhoids, except in children[b] *where the inoculating agent seems to be generally the ascarid.*[a]

These facts have in reality been known a long time. Since 1792 [? date], Rœderer and Wagler gave under the name of *morbus mucosus* the first account of an epidemic of typhoid fever, which they attributed to the large number of the intestinal worms which they encountered at the autopsies. These worms, already seen by Morgagni, but new for them, were nothing but whipworms, which they described under the name *Trichuris* [1761]. In 1807, Pinel in his *Nosographie philosophique* indicated that it is necessary always to suspect the existence of intestinal worms in mucous fevers. Rokitansky expressed an opinion analogous to that of Rœderer and Wagler. For Raspail, the term typhoid would be synonymous with an excessive infection [pullulation] with whipworms in the intestine. Finally, Davaine himself has noted the striking abundance of whipworms in typhoid fever. This last observation has a special interest in that Davaine, in denying any infectious rôle to the intestinal worms, urged the present medical conceptions. A number of good observers have thus been struck by the frequency of whipworms in the intestine of typhoids and have admitted a relation between the helminths and the infectious malady.

For us, our opinion is the following: An individual whose intestine is free from intestinal worms may drink [564] *with impunity contaminated water. But if this same water reaches an intestine containing whipworms, as these (in order to draw the blood with which they nourish themselves) penetrate into the intestinal mucosa with their pointed anterior end, they inoculate, at the same time, the bacteria into the mucosa, and they give rise to the infection. One thus understands better why, in a population drinking contaminated water, there are in reality so few individuals attacked; these are the persons who harbor intestinal worms, and more particularly the whipworms.*[a] How, otherwise is it to be explained that the bacillus is able to pass the barrier which the intestinal epithelium offers.[c] It is very evident that an ascarid, a fly larva,[d] or any parasite capable of wounding the intestine may act in the same way, but as the whipworm is the most common intestinal worm and at the same time that which wounds the mucosa the most deeply, it results that this is the one which should be nearly always incriminated.

One might object that the lesions of typhoid fever are found especially in the small intestine, while the whipworm is considered a normal parasite of the cecum. It is indeed exact that the adult whipworm fixes itself to the mucosa of the cecum, but it is known, since the experiments of Davaine, that the egg with the embryo hatches out in the stomach. It is thus permitted to suppose that the first stages of the free [parasitic] life are passed in the small intestine and that one is able, consequently, to observe in the latter the whipworms in different stages of development. In fact, Wrisburg has found them in the duodenum, and his observation is especially interesting in that he says that he has seen them enter, with one of their extremities, into the orifice of the glands of [565] Peyer and of the mucous follicles. Further, Heller has seen several

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[a] Italics not in the original.

[b] See, however, p. 210 of this report.

[c] See Thebault, 1901, 353: "This interesting observation is very demonstrative; it concerns a young girl who was accustomed to eating cheese in which the larvæ of *Piophila casei* were swarming."

[d] In connection with this phase of the subject, Guiart does not cite the experiments with tubercle bacilli and fat.

times in the small intestine some specimens which seemed to be smaller than those in the cecum. Werner and Bellingham have found them in the lower portion of the ileum; Davaine says that they have sometimes been found in the small intestine; finally, Bavay assures us that he has frequently encountered them in the small intestine of typhoids.

Further, even supposing that the whipworms live only in the cecum, the contradiction would be only apparent. The researches of numerous authors have established that, in fact, the inoculation of animals with cultures of the typhoid bacillus, even by intravenous or by intraperitoneal injection, is able to produce intestinal lesions. With greater right we ought not to be astonished to observe these lesions as a result of the inoculation of the bacillus in the region of the cecum. *That which it is important to retain is that typhoid fever is an infectious microbic malady, with intestinal port of entrance, and that it is the whipworm, an intestinal parasite, which, in the majority of cases, opens the door to the infection.*[a]

The practical consequences of these observations are of the highest importance. In fact, if in typhoid fever the initial etiologic agent is only the whipworm, it is that which it is necessary to attack.[a] Ordinarily, one contents himself, forewarned, to treat expectantly and one respects with the greatest care the intestine, for fear of increasing the ulceration; but the whipworms continue their inoculations, and thus by this method one does that which is necessary to augment the infection.

Thus, we conclude as follows: In presence of any febrile enteritis, even before knowing whether the serum-diagnosis is positive and whether it is necessary to incriminate Eberth's bacillus, one should institute, as soon as possible, the anthelminthic treatment and evacuate the intestine, in order to expel at the same time the microbes and the worms and to prevent the constant auto-inoculation of the patient. It would evidently be better to make an examination of the fecal matter and to vary the treatment (thymol, santonine, etc.) according to the eggs of the worms encountered. But, in practice, since it is nearly always [566] *the whipworm, one may content himself with instituting as rapidly as possible the anthelminthic treatment with thymol.*[a] * * *

What we have just said of the intestinal worms could be extended to all the parasites of the intestine, to the infusoria and the flagellates, as well as to the larvæ of insects, and in general to all parasites able to produce alterations of the mucosa. We know, in fact, one observation in which the larvæ of the cheese fly were able to produce an intestinal hemorrhage and caused an affection with a typhoid course, which was cured by the expulsion of the larvæ.

If these facts are confirmed and multiplied, the parasites of the intestine are going to retake the preponderating place which the intestinal worms formerly occupied in pathology. * * *

In an earlier paper, Guiart (1905, Jan. 15, 175–186) presents practically the same argument which he brings forward in Guiart and Grimbert (1906a), but he amplifies his arguments slightly in regard to the protozoa as inoculating agents in intestinal bacterial infections.

In connection with this amplification it may be pointed out that protozoa of various kinds are exceedingly common in the intestine. While admitting that certain protozoa are certainly capable of injuring the mucosa, there are others in connection with which this pathogenic action has not yet been demonstrated. It is therefore in the interest of conservatism to await rather convincing proof before unreservedly accepting protozoa as a very common inoculating agent.

[a] Italics not in the original.

In considering Guiart's theory, all authors will, I believe, admit that it is an exceedingly tempting one, and that the evidence which Guiart has submitted in its favor, while not convincing, is suggestive, and sufficient to demand an attentive consideration and an attempted confirmation. The claim that a wounded intestinal mucosa offers favorable points of attack for bacteria may also be admitted.

The practical point to be considered here is whether whipworms or other intestinal worms are as common in typhoid cases in Washington, D. C., as Guiart reports them for France, and as Viraldi and Tonello report for Italy. This question is especially important in view of the fact that the European statistics are not very extensive and that it has not been shown whether the high percentage of helminthiasis in these cases was not perhaps due to some special conditions. That this latter supposition is not excluded is seen from the fact that Stiles & Garrison (1906a, 50) have shown that whipworms were nearly twice as common (6.80 per cent.) among the sailors (Guiart's patients were apparently sailors or soldiers) as among the civilians (3.78 per cent.) admitted to the Government hospital from the District of Columbia; further, also, by the fact that Stiles & Garrison (1906a, 56–58) have shown that whipworm infection may vary from 0 to 75 per cent in different wards of the Connecticut hospital among patients not suffering from typhoid.

INVESTIGATIONS IN THE WASHINGTON EPIDEMIC.

SOURCE OF MATERIAL.

The 200 specimens of feces used were collected by the local board of health from cases of typhoid reported to the health officer during the months of July–September, 1906. Not all cases which occurred were examined, but the 200 cases which were examined were taken at random from those which were reported; hence they were not subject to any selective process, and may therefore safely be taken as basis for study.

TECHNIQUE.

The microscopic technique used was the same as that described in Stiles & Garrison (1906a, 10–11) except that because of the infectious nature of the material the specimens were collected in bottles instead of in paper, and trikresol was used instead of water. At least 10 preparations were made of each specimen, and, in most cases, at least two men worked independently on the slides, so that there were very few cases in which either a positive or a negative diagnosis depended upon the observations of one man. For instance, I examined from 2 to 8 preparations of the majority of cases, and the remaining preparations were examined by Doctor Goldberger, Mr. Willets, or Mr. Paterson.

ACKNOWLEDGMENTS.

It is a pleasure to acknowledge my obligations to Doctor Woodward, health officer of the District of Columbia, for arranging for the collection of the material, and to Doctor Goldberger, Mr. Willets, and Mr. Paterson for their aid in the examination of the slides.

SPECIES OF PARASITES FOUND IN THE STOOLS.

Only two species of worms were found in the 200 patients examined. These were the whipworm (*Trichuris trichiura*) and the eelworm (*Ascaris lumbricoides*). In several preparations live or dead mites were found. While it is perhaps doubtful whether these mites would come into consideration in connection with the theory in question, mention will be made of them in the statistics.

CONCURRENT INFECTIONS.

In only one case was there a concurrent infection with whipworms and eelworms. All other cases infected with worms were infections with a single species.

FREQUENCY OF INFECTION.

Before giving the number of verminous infections actually found, it will be well to estimate the number (endemic helminthiasis) which might be expected in our 200 patients, independent of the question of typhoid.

Endemic helminthiasis.—Our patients are classified as follows:

Sex.	Whites.	Negroes.	Total.
Male	77	28	105
Female	59	36	95
Total	136	64	200

It will thus be seen that we had 68 per cent. whites, 32 per cent. negroes; 52.5 per cent. males, 47.5 per cent. females.

The latest statistics on the population of the District of Columbia accessible to me (police census, spring of 1906) give the corresponding figures for the entire population as follows:

Sex.	Whites.	Negroes.	Total.
Male	113,348	43,955	157,303
Female	118,069	51,063	169,132
Total	231,417	95,018	326,435

Thus, these statistics give 70.89 per cent whites, 29.10 per cent negroes, 48.18 per cent males, 51.81 per cent females.

It will thus be seen that we have, in our 200 cases examined, a slight excess of males and negroes and a slight deficit in whites and females, when compared with the total population of the District of Columbia. It should, however, be recalled that our examinations were made from the latter part of July to the first week in September, inclusive, and that because of the severe and trying climate of these months in Washington, there is quite an appreciable change in the proportions of whites to negroes and males to females, due to the exodus of many of the inhabitants who desire to escape this hot season; the financial condition of the inhabitants naturally results in a greater exodus among the whites than among the negroes, and the official and business duties devolving upon the men naturally result in a greater exodus of women than of men.

The division of the cases, therefore, corresponds approximately to the division of the general population, hence it forms a fair basis for study.

Stiles & Garrison (1906a, 13–14) have shown that 746 whites admitted to the Government hospital from the District of Columbia showed an average intestinal helminthiasis of 4.96 per 100 persons, and an average of 3.75 per cent. infection with whipworms; also, that 378 corresponding negroes presented an average of 12.43 per 100 persons of general intestinal helminthiasis, and 9.79 per cent. infection with whipworms. The approximate number of infections which might occur among our 200 patients, without causing any surprise, would thus be as follows:

Race.	Total intestinal helminthiasis.	Infection with whipworms.
Whites	136× 4.96=6.7456	136×3.75=5.1000
Negroes	64×12.43=7.9552	64×9.79=6.2656
Total	14.7008	11.3656

Thus we might expect among our 200 patients, 14.70 cases of intestinal helminthiasis and 11.36 cases of whipworms, without giving us any ground for assuming that the intestinal worms had anything to do with the typhoid infection, either directly or indirectly. As a matter of fact, we might expect even a slightly higher number of infections than these figures indicate, for this has been an unusually wet year, hence one favorable to whipworm and ascaris infections.

The infections found among the 200 typhoid patients were as follows:

Race and sex.	Number examined.	Examination negative.	Infections.			Total cases infected.
			Trichuris.	Ascaris.	Mites.	
Whites:						
Males	77	68	[a] 7+1	[a] 1+1	0	9
Females	59	53	5	0	1	6
Total	136	121	12+1	[a] 1+1	1	15
Negroes:						
Males	28	27	0	0	1	1
Females	36	33	1	0	2	3
Total	64	60	1	0	3	4
Grand total	200	181	[a] 13+1	[a] 1+1	4	[b] 19

[a] One concurrent infection of *Ascaris* and *Trichuris*.
[b] Including the cases harboring the mites, which however are not true parasites.

It is thus seen that while we might expect that our 200 patients would show (independently of the fact that they had typhoid) approximately 15 (14.7) verminous infections, they actually did present (despite their typhoid infections) 16 infections (in a total of 15 persons); 4 additional cases (2 per cent.) presented either live or dead mites in the feces, but these may probably be ignored; and 185 patients (92.5 per cent.) showed no intestinal worms.

Further, while we might expect that 11 or 12 of the patients (11.36 cases, or 5.68 per cent.) would present infection with whipworms (independently of the fact that they had typhoid), 14 patients (7 per cent.) actually did have whipworms.

Thus, in the 200 typhoid patients, the increase (over what might have been expected had they not had typhoid) was only 1.3 infections (0.65 per 100 persons) excess in general helminthiasis, and only 1.32 per cent excess in infection with whipworms. These slight excesses can hardly be considered as of importance in connection with the typhoid fever when we recall that 92.5 per cent. of all the patients showed no intestinal worms whatever, and when, further, we take into consideration the unusually wet weather which has prevailed this year.

It is rather interesting that the excess in whipworms was due to an excess of infection among the whites, which gave a total of 9.55 per cent whipworms against 3.75 per cent which we expected to find. Still, this excess of 5.80 per cent. can hardly be considered as of significance in connection with the typhoid when we note that the negroes gave only 1 case of whipworms, or 0.5 per cent, instead of 6 cases, or 9.79 per cent., which we might have found without exciting any surprise.

It will be noticed that Guiart (Guiart & Grimbert, 1906a, 562) examined 1 typhoid case microscopically without finding evidence of whipworm infection, but such infection was found upon autopsy. The possibility is present that the worms were all males, or that if females were present they were not ovipositing. If we had only a few negative cases, the same possibilities would arise for consideration in our study, but with negative results as to the whipworms and eelworms (exclusive of the mites) in 185 cases, or 92.5 per cent. of our cases, it hardly seems probable that such possibility (of only male infection or of nonovipositing females) would arise in 185 patients.

Thus it is seen that the statistics of helminthiasis in the Washington typhoid epidemic of 1906 do not support the theory that the intestinal worms have any necessary or any very common connection as an inoculating agent in this disease.

SEVERITY OF HELMINTHIC INFECTION.

It will be noticed from the review of Guiart's papers that he lays some stress upon the severity of the infection with whipworms in typhoid cases, as judged from the number of eggs in the preparations. He found that they presented an average of 2 eggs per slide, which was about 14 times as high as he found in a nontyphoid case of infection with whipworms.

Our 14 cases varied from 1 to 19 eggs in 10 slides, a total of 67 eggs in 140 slides, or an average of 0.47 + egg per slide. I have no exact statistics of the intensity of whipworm infection in nontyphoids for this District with which these figures can be compared, for in former work on fecal examinations the findings in this respect have not been summarized statistically. Simply as a matter of impression it occurred to both Mr. Willets and myself that the infections found in these typhoid cases averaged rather low when compared with the infections we found at the Government hospital several years ago in nontyphoids.

TYPHOID AND WHIPWORM INFECTION COMPARED INDIRECTLY.

In respect to age of patient.—According to statistics summarized by Stiles & Garrison (1906a, 71) whipworms are more common (16.80 per cent of 2,381 persons) in persons below 15 years of age than at any later period of life; from 5 to 10 years of age the infection of 203 persons averaged 25.62 per cent. In examinations made in this laboratory whipworm infection varied (see Stiles & Garrison, 1906a, 24) as follows:

Age of persons.	Number examined.	Whipworm infections.		200 cases of typhoid, 1906, arranged by ages.		Total cases of typhoid, 1906, arranged by ages.	
		Number.	Per 100 persons.	Number of cases.	Per cent.	Number of cases.	Per cent.
Under 15 years	123	16	13.01	55	27.5	271	31.3
15 to 30 years	572	50	10.49	[a] 95	47.5	[a] 406	46.9
31 to 50 years	1,341	116	8.65	[b] 42	21.0	[b] 165	19.0
Over 50 years	1,289	60	4.65	[c] 7	3.5	[c] 24	2.8
Unknown				1			

[a] 15 to 29 years, inclusive. [b] 30 to 49 years, inclusive. [c] 50 years and over.

At the right of the above table, in their respective age groups, are given the number of cases of typhoid examined this summer for whipworms, and the total number of cases studied by the board. The percentages of the two typhoid groups (200 cases and total cases) vary slightly, but not sufficiently to indicate that the 200 cases form an unfair basis for comparison.

If whipworms form the common inoculating agent of typhoid, it is not unreasonable to expect that there should be some general parallel between the age groups of typhoid and of whipworm infection. From the above table it will be seen that the maximum typhoid age group (15 to 29 years) of the cases we examined does not correspond with the maximum group (under 15 years) of whipworm infection for this climate; further, while there is a decrease in both typhoid and in whipworms in the next two age periods (31 to 50 years, and over 50 years) this decrease is not even approximately parallel.

Thus typhoid and the whipworm infections compared on basis of ages of patients examined in this laboratory do not agree in the age groups of highest infection, while the percentages in the remaining groups are not even approximate; hence, from this point of view, the theory under discussion receives no support from the present investigation.

The comparison made in the foregoing is in so far open to objection that in the case of whipworm infection the percentages represent a comparison of the infected persons with the total number of persons in the different age groups; while in the typhoid cases the percentages of infection represent a comparison of the number of patients of any given age group with the total number of patients. Thus the comparison is not mathematically exact. Nevertheless, this objection is not so serious as might at first be assumed for the statistics on worms give the mathematical probabilities of infection for a given person in the respective age group; and since, under normal conditions, the proportions in inhabitants will decrease from the youngest to the oldest age group, since further (from the standpoint of the verminous theory) a greater number of persons under 15 years would

be subject to typhoid than of persons between 15 and 30 years, we should still expect (according to the theory) that the age period under 15 years would necessarily present a greater proportion of the total number of typhoid patients than would the age group 15 to 30 years.

In respect to sex of patients.—Stiles & Garrison (1906a, 70) have shown that in cases collected from literature (1,543 males and 810 females examined) the whipworm infection was 17.30 and 20.37 per cent, respectively. In their own work 2,311 males and 1,146 females examined at the laboratory showed 6.45 and 10.21 per cent infection, respectively, with whipworms. Thus from both the literature at large and the results of examinations at this laboratory (based upon patients at the Government and at the Connecticut hospitals) the infection with whipworms is more common among females than among males.

Of the 200 cases of typhoid examined this summer for helminthiasis, 52.5 per cent were males and 47.5 per cent were females (see, however, paragraph as to summer population, p. 208). Of the total number of cases of typhoid (866) studied by the board, 588 cases (67.9 per cent) were males and 278 cases (32.1 per cent) were females.

Accordingly the relative number of infections of typhoid in males and females were not altogether in harmony with the relative number of probable whipworm infections in males and females, as judged either from the literature at large or from our own examinations.

In patients from the District of Columbia, however, Stiles & Garrison (1906a, 18) report a slightly higher rate of intestinal helminthiasis among males than among females (8.68 and 6.20 per 100 persons, respectively), figures which are slightly more in harmony with the theory under discussion.

In respect to race of patients.—Stiles & Garrison (1906a, 13) have shown that in the District of Columbia 746 whites and 378 negroes examined as to intestinal helminthiasis presented 4.96 and 12.43 infections per hundred, respectively. The percentage of whipworm infection was 3.75 and 9.79, respectively.

If whipworms bear any necessary or common relation to typhoid, we should therefore expect to find in the District a much higher typhoid rate per 1,000 inhabitants among the negroes than among the whites. Giving the theory any mathematical advantage it may derive from the change in the Washington population during the summer, it may be recalled (see p. 207) that the whites represent approximately 71 per cent, the negroes approximately 29 per cent, of our inhabitants. Assuming an equal exposure to infection (although this assumption gives the negro an advantage in the statistics) and an equal susceptibility to typhoid (a point which is still *sub judice*)

we may divide our 136 white cases by 2.45 [a] in order to bring them on approximately the same comparative basis as the negroes.

Thus we have $136 \div 2.45 = 55.5$ white cases to compare with 64 negro cases of typhoid (compared on *approximately* the same basis), despite a whipworm infection of 3.75 per cent in nontyphoid whites and 9.79 per cent in nontyphoid negroes in the statistics quoted above (p. 212).

Accordingly a comparison of our 200 cases of typhoid with whipworm and the general infection in the District of Columbia with respect to the race of the patients shows that there was a very slight excess (in proportion to inhabitants) of typhoid among the negroes we examined over this disease among the whites. This excess in no way compared, however, with the mathematical probabilities of whipworm infection or of helminthiasis in general, and it is therefore possible that it was due to some other cause. Considering, now, the change in our summer population, whereby the negroes form a greater percentage, it seems possible that the typhoid excess in negroes may have been due, at least to some extent, to that factor.

The board had records of a total of 866 cases reported as typhoid. Of these, 588 were whites and 278 were negroes. Reducing these to a basis for approximate comparison ($588 \div 2.45 = 240$) we have for the entire outbreak 240 cases of typhoid among the whites to be compared with 278 cases among the negroes. If the proportion obtained from the cases examined for worms (55.5 to 64) is extended to the entire number of cases we should expect 241.08 white cases to 278 negroes—figures which are approximately the same as those actually obtained (240 to 278). The 200 cases examined for worms form, therefore, a fair basis for testing the theory of inoculation by worms.

It may be frankly admitted that the indirect evidence submitted in the foregoing in reference to age, sex, and race of the patients is open to the criticism that it is only approximate. Were the results of the microscopic examinations themselves less at variance with the theory under discussion, it would be incumbent upon me to work out the indirect evidence on a stricter mathematical basis, but with such strikingly negative results in the microscopic work the indirect evidence seems very secondary, and on this account approximate statistics will suffice.

Date of manuscript, December 13, 1906.

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[a] 29 [per cent negroes]: 71 [per cent whites]=100 [negroes]: 245 [whites], in population; hence divide white cases (136) by 2.45 to reduce white and negro cases to a comparison on basis of relative population.

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IX.—PREVIOUS REPORTS UPON TYPHOID FEVER IN THE DISTRICT OF COLUMBIA.

PREVIOUS REPORTS UPON TYPHOID FEVER IN THE DISTRICT OF COLUMBIA.

We find the literature upon this subject so widely scattered and some of the reports so difficult to obtain that we have brought together in brief review a collection of the following important papers upon the subject.

We are indebted to Dr. G. L. Magruder and to Dr. George M. Kober for papers and reprints from their private collections, and also for information upon the history of previous investigations.

A CONTRIBUTION TO THE ETIOLOGY OF TYPHOID FEVER.[a]

[By George M. Kober (1891).]

In this paper Dr. George M. Kober reviews the part played by soil pollution, impure water supplies, etc., and also the peculiar individual predisposition favoring the occurrence of typhoid fever, and calls attention to the fact—

that the city of Washington is supplied with Potomac River water, and although the distance of the run is nearly 150 miles, it is a notable fact that enteric fever prevailed to an unusual extent from December, 1889, to April 30, 1890. Doctor Pool, of the health office, informs me that the deaths for these months from typhoid fever amounted to 75, as compared with 42 for the corresponding months of last year. This can not be explained by increased population. Perhaps it is only a coincidence, but it may also confirm the conclusions of the English River Pollution Commission that "nothing short of the abandonment of the inexpressibly nasty habit of mixing human excrement with our drinking water can confer upon us immunity from the propagation of epidemics through the medium of potable waters.

REPORT ON TYPHOID FEVER IN THE DISTRICT OF COLUMBIA.

[By G. L. Magruder, W. W. Johnston, and C. M. Hammett, Committee of the Medical Society of the District of Columbia, Washington, Government Printing Office, June 14, 1894.]

This interesting and instructive report first reviews the prevalence and mortality of typhoid fever in the District from 1881 to 1893, finding an almost uninterrupted increase from 1881 (67 deaths) to 1890 and 1891 (208 deaths). In 1892 and 1893 there was a decrease, the deaths numbering 183 and 186, respectively.

Mention is made of the large number of deaths reported from "typho-malarial" and malarial fevers in the District, and the opinion

[a] Reprint Verhandl. des X. internat. med. Congresses. Berlin, 1891.

is expressed that many of these cases were really typhoid fever. Attention is called to the fact that as malarial fevers are diagnosed less, the diagnosis of typhoid fever has become more frequent. Also that the areas of the greatest number of deaths from malarial fevers, typho-malarial fever, and diarrheal diseases coincide with that of typhoid fever.

Abundant water supply and efficient sewerage being so intimately associated, it was found very difficult to determine what effect separately these conditions had upon typhoid fever. Instances are cited to show that it has been necessary to combine good water with efficient sewerage before there was any marked reduction in the typhoid rate.

It was found that the greatest abundance of bacteria in Potomac water occurred in January and February, the season of least typhoid in Washington, while during August, September, and October, when typhoid was most prevalent, the bacterial counts were lowest. Also that turbidity and bacteria ran parallel, in accordance with the rainfall on the Potomac watershed. The conclusion is reached that the possibility of the introduction of typhoid bacilli into Potomac water is dependent upon the prevalence of the disease on the watershed, but that "it is an unjustifiable conclusion that because fecal bacteria are found in Potomac water, therefore typhoid fever is usually propagated by the drinking of Potomac water."

The authors show that the disease was more prevalent in that portion of the city occupying the low ground in the southeast and southwest, and attribute this fact to several causes, viz, a greater number of privies in those localities, resulting in greater pollution of the soil; leakage from defective drains, and less efficient drainage on account of the flatness of the land and the backing up of the tidal currents into the sewers, even in times of flood, carrying the sewage into cellars and basements.

On account of the greater soil pollution, it was found that the wells of this section were often contaminated.

The authors did not investigate the milk supply sufficiently to warrant any extended remarks, stating that—

it is safe to assume from the experience of many observers elsewhere that typhoid fever is to a certain extent propagated by milk; there is nothing in the condition of the dairies from which our milk supply is drawn to make us think that we are better protected from this danger than other communities where epidemics have been traced to milk infection.

The conclusions are reached that:

1. Typhoid fever increases in proportion to the saturation of the soil with decomposing organic matter, especially human excreta, and to the drinking of infected water.

2. Typhoid fever decreases in proportion as a city is well sewered, and in proportion to the abandonment of the drinking of well water, and of all contaminated water.

Also:

The daily pollution of the soil by the fecal discharges of our patients suffering from typhoid fever with the resulting contamination of well water must be recognized as the chief source of the diffusion of the disease.

They recommend:

1. The immediate abandonment of all wells within the city limits, exception only to be made in case of absence of Potomac supply and when the wells, after repeated chemical and bacteriological examinations, have been found to be free from all possible sources of danger; but even these to be abandoned as rapidly as possible.

2. Purification of the sewerage system already existing by replacing as rapidly as possible all damaged and defective drains.

3. The introduction of new sewers in advance of other improvements in parts of the city not now supplied with drainage and the system as far outside of the city limits as the rapidly growing population demands, so as to prevent soil contamination.

4. The adoption of some system by which the lower sections of the city can be more completely drained and risks arising from the backing up of tide water and sewage prevented.

5. The final and safe disposal of sewage.

6. To make all existing privies, vaults, or other receptacles of human excreta water-tight, and by rigid inspection and penalties to prevent the danger from leakage and overflow.

7. The early completion of the plans recommended by Colonel Elliott, in charge of the Washington Aqueduct, and now in course of execution, which have in view the sedimentation of the Potomac water, and ultimately the completion of works for filtration, the only proper method of purification.

8. The suppression of all privies and the enforcing of the law to make sewer connections.

9. Careful inspection of all dairies in the District from which our milk supply is drawn, and the enactment of a law by which no milk shall be sold in the District without a permit from the health office. The inspection should cover an examination at the dairies of all possible sources of infection, including the water supply.

10. The urging upon the members of the profession of a careful collation of all the facts bearing upon the mode of infection in each case and the advantage of reporting such facts to the society, and the propagation of the doctrine that immediate disinfection of the stools is the first duty of the physician as guardian of the health of the community.

RELATIONS OF WATER SUPPLY AND SEWERS TO THE PUBLIC HEALTH OF CITIES, WITH SPECIAL REFERENCE TO THE CITY OF WASHINGTON.[a]

[By George M. Kober (1897).]

Dr. George M. Kober, in an address before the Civic Center, January 15, 1897, referred to the unusual typhoid situation in the District of Columbia, and submitted the following resolutions, which were passed by the Civic Center:

Whereas the statistics of the health officer of the District of Columbia indicate an almost uniform increase and excessive prevalence of typhoid fever during the past fifteen years; and

[a] Public Health Reports, U. S. Marine Hospital Service, vol. 12, Feb. 26, 1897, p. 197.

Whereas the experience of the civilized world points to a contaminated water supply as the most important factor in the causation of this disease; therefore be it

Resolved, That we, the Civic Center of the City of Washington, a body composed of members who are working for the public good, most earnestly pray the Senate and House of Representatives in Congress assembled that you will create a commission * * * for the purpose of determining the present sources of contamination of the Potomac River, and the measures necessary to remedy, remove, and prevent such pollution, if found to exist.

REPORT OF THE BACTERIOLOGICAL EXAMINATION OF POTOMAC WATER FROM JULY 1, 1897, TO FEBRUARY 28, 1898, INCLUSIVE.[a]

[By Passed Assistant Surgeons J. J. Kinyoun and E. K. Sprague.]

Passed Assistant Surgeon J. J. Kinyoun, director of the Hygienic Laboratory, and Passed Assistant Surgeon E. K. Sprague, of the Marine Hospital Service, made a systematic study of the bacteria in Potomac water during the period stated.

Analyses of Potomac water were made semiweekly from a constantly flowing tap in the Hygienic Laboratory, using 20 cc. at each examination. To insure uniform results, a sufficient quantity of media was made in the beginning to last during the entire time.

If the inoculations failed to produce organisms showing motility or fermentation, no further examination was made of that individual specimen. Those showing these characteristics were further studied and identified, Elsner's medium being used to isolate the bacillus of typhoid fever and the colon bacillus.

In no instance was the typhoid bacillus found, but on numerous occasions colon bacilli were isolated. The colon bacillus, with others of this group, were taken as an index of water pollution.

Turbidity and bacteria were found to correspond fairly accurately, but it was very clearly shown that during the period of least turbidity and bacteria, the sewage organisms, especially colon bacilli, were relatively much more abundant. The percentage of times colon bacilli were found was December and January, 20 per cent; September and October, 70 per cent.

Attention is called to the parallelism existing between the death rate from typhoid fever, the percentage of times colon was found, the fermentation, and the temperature curve; but at the same time that the above were high the number of organisms per cubic centimeter was low.

The anærobic bacteria were present in greater numbers in proportion to the ærobic during the heated season than at any other season of the year, and as they are a fairly accurate index to the amount of sewage contamination the conclusion was drawn that from August to November the Potomac River is more dangerously polluted than during other seasons. During the late summer and early autumn there is less rainfall to wash nonpathogenic organisms

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[a] Annual Report, Marine Hospital Service, 1898.

into the river; hence the low counts. There is, however, an increase in the quantity of house sewage at this time of the year; hence a relative increase in the number of dangerous bacteria.

Taking all these circumstances into consideration, it will be readily understood that instead of the coincidence of the highest typhoid rate with the lowest bacterial counts being a contradictory condition, it is exactly what it is to be expected.

The authors draw this final conclusion:

That the typhoid death rate, the presence of colon bacilli, the fermentation changes in the media, and the temperature should coincide with one another is perfectly logical, and there is but one conclusion that can be drawn therefrom—the increased mortality from typhoid and diarrheal diseases is due to the increase in the quantity of bacteria from the intestines of man, which our citizens are compelled to digest at that time.

Sand filtration was recommended as the most practical method of purifying the water.

NECESSITIES FOR THE PREVENTION OF POLLUTION.[a]

[By G. M. Kober (1898).]

In this valuable paper Doctor Kober considers the typhoid-fever epidemic at Cumberland, Md., and its effects upon the city of Washington.

In reference to our Potomac River, which is by no means a type of the most polluted American rivers, we know that it receives the sewage of Frederick, Cumberland, and Harper's Ferry, besides that of about 25,000 people living in smaller towns and settlements along the watershed.

My suspicions that the typhoid germs may travel all the way from Cumberland and infect susceptible persons in Washington were confirmed as early as the winter of 1889–90 by studying the effects of the typhoid epidemic at Cumberland upon the prevalence of the disease in this city.

The records of the health office show that during this epidemic, from December, 1889, to April, 1890, the deaths from typhoid fever amounted to 74, as compared with 42 for the corresponding months of the previous year. Indeed we had almost double the number of typhoid deaths during these months than for any similar period either before or since this epidemic.

Cumberland had about 45 deaths and 485 cases; this city had 74 deaths and about 740 cases, and yet the starting point of all was the excreta of one patient washed into a little run which empties into the Potomac about 300 feet above the pumping station at Cumberland. In the face of this fact I have no hesitation in declaring that our excessive typhoid rate is largely due to contaminated Potomac water.

Doctor Kober further considers the sources of river water, the character and extent of pollution, the significance of intestinal bacteria in the water, the self-purification of rivers, why all persons are not infected with typhoid fever, remedial legislation by Congress, and

[a] Report on the pollution of rivers, by Henry Talbott, chairman of Committee on River Pollution, to the Game and Fish Protective Association of the District of Columbia. Washington, Government Printing Office, 1898, p. 32.

what will be accomplished by the prevention of river pollution, giving many interesting figures, showing the comparison between the typhoid death rates in Washington and other cities.

WATER SUPPLY AND SEWAGE DISPOSAL IN THE DISTRICT OF COLUMBIA.[a]

In this report Dr. Samuel C. Busey recounts the history of the efforts to secure a better water supply for the city of Washington, giving credit especially to Dr. G. Lloyd Magruder, to whom must be awarded the merit of initiating an investigation which placed the Medical Society of the District of Columbia in the front in efforts to secure a better water supply for Washington.

This report dwells especially upon typhoid fever as a water-borne disease, giving many instances, and especially lauds the value of slow sand filtration, and asks, "Is it not reasonable to presume that if filtration were adopted for this city there would be a greater diminution in typhoid fever?"

In this report Doctor Kober was the first to call attention to the effects of the Dalecarlia reservoir as a sedimenting basin upon the typhoid-fever death rate of Washington.

> It is well known that sedimentation plays an important part in the purification of water, and I will now direct your attention to figures which show what influence this method alone has exercised upon our typhoid-fever rates. The subjoined table gives the typhoid-fever rate in this city from July, 1879, to January 1, 1898. * * *
>
> The Dalecarlia reservoir was in almost uninterrupted use as a sedimentary basin from July 1, 1879, to June 3, 1885. Mark the comparatively low typhoid fever rates: From June 3, 1885, to July 28, 1886, the sedimentary basin was not in use; note the difference. From July 28, 1886, to April 6, 1887, it was in use; note the decline. Again mark the decided increase when not in use from June 20, 1888, to July 28, 1895, and the decided decline since its use in August, 1895. It should be remembered that of the 228 cases which occurred from July 1, 1895, to June 30, 1896, 194 deaths occurred in 1895, and only 34 in the six months ending June 30, 1896. The very high rates for August to October are unaccountable, unless due to local pollution while the reservoir was out of service. This table speaks for itself, and that bacterial purification does take place in sedimentary basins can not be questioned.

This document contains, further, a discussion by Dr. J. J. Kinyoun, then director of the Hygienic Laboratory, Marine-Hospital Service, and by Dr. Charles Smart, Deputy Surgeon-General, U. S. Army.

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[a] Report of the Committee on the Public Health of the Medical Society of the District of Columbia on the water supply and sewage disposal in the District of Columbia, and the discussion thereon. February 23, 1898. 55th Cong., 2d sess., S. Doc. No. 183.

RELATIVE MERITS OF SLOW SAND AND MECHANICAL FILTRATION.[a]

This document contains a report by Dr. Samuel C. Busey, Dr. G. Wythe Cook, Dr. George M. Kober, Dr. Z. T. Sowers, and Dr. William C. Woodward, a committee of the Medical Society of the District of Columbia, upon the relative merits of slow sand filtration and mechanical filtration with special application to the problem in Washington. After comparison of the two systems the installation of slow sand filtration is urgently recommended.

THE RELATIVE MERITS OF THE MECHANICAL AND THE SLOW SAND SYSTEMS OF FILTRATION FOR THE WATER SUPPLY OF THE DISTRICT OF COLUMBIA.[b]

This document contains a report by Messrs. Rudolph Hering, George W. Fuller, and Allen Hazen. In consideration of the full evidence they recommend the construction of a complete system of slow sand filters with such auxilliary works as may be necessary for preliminary sedimentation and the use of a coagulant for a part of the time. There is no reason to believe that the use of this coagulant will in any degree affect the wholesomeness of the water.

PURIFICATION OF THE WASHINGTON WATER SUPPLY.[c]

This document contains a discussion upon sand filtration in relation to typhoid fever with special reference to the comparative merits of slow sand filtration of the English system and mechanical filtration with coagulation known as the American system. Those who took part in the discussion were Messrs. Rudolph Hering, George W. Fuller, Allen Hazen, J. M. Diven, E. B. Weston, John W. Hill, George A. Johnson, Dr. J. S. Billings, and Prof. William P. Mason.

This document also contains letters from Dr. H. D. Geddings, of the Marine-Hospital Service, Lieut. Col. Charles Smart, U. S. Army, and Mr. Robert Spurr Weston upon the filtration of public water supplies with special reference to the Potomac River. There is also an extract from the report of the committee on the public health of the Washington Board of Health and other historical and documentary matter bearing upon the subject.

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[a] Report made by a special committee of the Medical Society of the District of Columbia upon the relative merits of slow sand and mechanical filtration. 56th Cong., 2d sess, S. Doc. No. 27. [December, 1900.]

[b] 56th Cong., 2d sess., S. Rept. No. 2380. [February, 1901.]

[c] An inquiry held by direction of the United States Senate Committee on the District of Columbia. Edited and compiled by Charles Moore, clerk of the Senate Committee on the District of Columbia. Washington, Government Printing Office [February 19], 1901. 56th Cong., 2d sess., S. Rept. No. 2380.

FEASIBILITY AND PROPRIETY OF FILTERING THE WATER SUPPLY OF WASHINGTON, D. C.[a]

This document contains a valuable report by Lieut. Col. A. M. Miller, Corps of Engineers, U. S. Army, upon the question of the Potomac River water and its relation to typhoid fever.

Chemical and bacterial analyses of the river water are given and the results of preliminary experiments with the English or slow sand filters and the American or mechanical filters are described. The recommendation is made that for the filtration of the Washington water supply the American or mechanical system of filtration be adopted.

The document also contains a report by Mr. E. D. Hardy, covering the performance of the experimental filters in detail.

It also contains a report by Mr. Robert Spurr Weston, giving the character and composition of Potomac River water, especially after subsidence in the system of reservoirs. Much valuable bacteriological and chemical data are summarized and the various systems of filtration as applied to the Potomac water compared. Mr. Weston concludes that the English system can be adapted to the clarification and purification of the Potomac River water by adding a coagulant to the water at times when the Potomac water, after subsidence in the system of reservoirs, would contain more than 15 parts of suspended matter per million.

The American system can be adapted to the clarification and purification of the Potomac River water by arranging for periods of coagulant and supplementary subsidence before filtration.

Both systems would, therefore, certainly improve the Potomac River water after subsidence in the system of reservoirs, and the choice between them depends entirely upon the comparative cost.

POLLUTION OF THE POTOMAC RIVER AND ITS RELATION TO THE WATER SUPPLY OF THE DISTRICT OF COLUMBIA.[b]

[By Marshall O. Leighton, United States Geological Survey (1900).]

The author states it as a general law that while a drainage area is inhabited the water of a river will inevitably be polluted, the damage increasing as the population increases.

Referring to the Potomac River, he considers it grossly abused. Foul and putrid matter is deposited in the main stream and its tributaries apparently without regard to the effects upon the interests

[a] Letter from the Secretary of War, transmitting copy of a communication from the Chief of Engineers, United States Army, submitting report of an investigation of the feasibility and propriety of filtering the water supply of the city of Washington. 56th Cong., 1st sess., S. Doc. No. 259. [March, 1900.]

[b] S. Doc. 181, March 1, 1905.

of those below. These facts are apparent to any observer without chemical or biological examination.

The amounts, kinds, and sources of pollution at the various points above Great Falls are reviewed in detail. The most serious sources of pollution in the Potomac basin are at considerable distance from Great Falls, but not sufficiently far to insure immunity from danger in the domestic use of raw Potomac water.

There are two classes of pollution—sewage and industrial wastes. By sewage is meant the wastes occurring in the life processes of mankind and those resulting from domestic economy. Industrial wastes are those resulting from any industrial process and which, having no tangible value, are rejected.

In the treatment of water containing sewage, the primary object is to remove pathogenic organisms. By filtration, a highly polluted water may, within reasonable limits, be made practically as pure as water containing only a small amount of sewage.

Industrial wastes offer more difficult and varied problems, on account of their more complex composition, difficulty of treatment, and varied effects. It involves detailed consideration of all the industries from which these wastes are derived. The effects of industrial wastes are various, and in nearly all cases highly detrimental. Some render the water too hard for domestic or industrial use, some impart tastes, odors, or colors to the water.

The author concludes that both kinds of pollution are on the increase, and that the sooner wise and prohibitory measures are taken the less trouble and expense will be incurred.

THE POLLUTION OF THE POTOMAC RIVER AND ITS DANGERS.[a]

[By Thomas N. McLaughlin, M. D.]

In the presidential address before the Medical Society of the District of Columbia, Doctor McLaughlin called attention to the importance of this subject to the people and physicians of Washington, illustrating some of the chief sources of pollution by means of lantern slides, showing graphically the conditions described.

Secondary to the pollution of rivers, the danger of infection by oysters fattened in fresh-water estuaries was particularly mentioned as of growing importance.

After discussion of results obtained by filtration of water supplies of other cities, he concludes that "The successful operation of any filtration system depends upon the care, trustworthiness, and experience of those employed to manage the system. The degree of purity of the filtered water is influenced by the length of time allowed for

[a] Washington Medical Annals, January, 1906.

sedimentation to take place, and the amount of pollution of the water, and its turbidity."

The following resolution was passed by the society and acted upon by the president:

Resolved, That the president of the society be authorized to appoint a committee of five for the purpose of inquiring into the efficiency of the city water-filtration plant, and to make such recommendations as may be deemed necessary to secure a clear and wholesome water supply.

X.—A SANITARY SURVEY OF THE DRAINAGE BASIN OF THE POTOMAC RIVER.

SANITARY SURVEY OF THE DRAINAGE BASIN OF THE POTOMAC RIVER

By Joseph Goldberger,
Passed Assistant Surgeon, Public Health and Marine-Hospital Service.

ACKNOWLEDGMENTS.

In the course of this survey I visited every town of importance on the watershed. To supplement my own observations I have drawn freely from an elaborate study of the hydrography of the Potomac River [a] about to be published by the hydrographic division of the United States Geological Survey, the manuscript of which was most generously lent to me by the chief hydrographer, Mr. M. O. Leighton.

To Prof. Willis L. Moore, Chief of the United States Weather Bureau, I am indebted for the data relating to precipitation and temperature.

DRAINAGE BASIN.

The Potomac River is formed by the junction of the North and South branches about 25 miles below Cumberland. From this point it flows in a southeasterly direction for a distance of 153 miles to the dam at Great Falls. It forms the boundary between Maryland on the north and Virginia and West Virginia on the south. In its course it has carved a passage almost at right angles across mountain ridges whose general trend is northeast to southwest, so that the numerous tributaries which it receives come from the north and the south and have the general direction of the ridges from whose steep sides the waters rush to form several streams of considerable size.

The North Branch rises at the Fairfax Stone in the western part of West Virginia and flows in a northeasterly direction through a tortuous steep-banked and quick-spilling valley. At Cumberland, about 80 miles from the Fairfax Stone, it curves sharply and winds its way in a southeasterly direction for a distance of 23 miles before uniting with the South Branch.

[a] Water Supply Paper No. 192, U. S. Geol. Survey.

The South Branch rises by two "forks" in the northern part of Highland County, Va. These flow in a northeasterly direction and unite about 6 miles west of Petersburg, W. Va. The South Branch, thus formed, continues in a northeasterly direction, and, as above stated, unites with the North Branch to form the main stream.

At Moorefield the South Branch is joined by the Moorefield River, a beautiful stream which rises in the northeastern corner of Highland County, Va.

At Harpers Ferry, 45 miles above Great Falls, the Potomac is joined by the Shenandoah River, which drains an area of about 3,000 square miles of the valley of Virginia, exceeding somewhat in its drainage area the combined areas drained by the North and South branches of the Potomac River. The Shenandoah is formed at Riverton, W. Va., by the confluence of the North with the South Fork. The South Fork of the Shenandoah rises by three "rivers," North, Middle, and South, in Augusta County, Va., which unite at Port Republic. The North Fork of the Shenandoah rises in the northwestern corner of Rockingham County, Va. The two forks, separated by Massanutten Mountain, take a general northeasterly direction, and, as has been stated, unite at Riverton to form the main stream, which continues in the same general direction to Harpers Ferry. There are several dams, besides shoals and rapids, which obstruct the smooth flow of this important stream.

The North Branch of the Potomac, before it is joined by the South Branch, receives several tributaries, the most important of which are New and Patterson creeks from the south, and Savage River, Georges Creek, and Wills Creek from the north. The main stream in its course, before it is joined by the Shenandoah, receives the Great Cacapon River, Back Creek, and Opequon Creek from the south, and Conococheague and Antietam creeks from the north.

Below Harpers Ferry and above Great Falls the Potomac is joined by Catoctin Creek (Virginia) and Goose Creek from the south, and by Catoctin Creek (Maryland), Monocacy River, Seneca Creek, Muddy Branch and Watts Branch from the north.

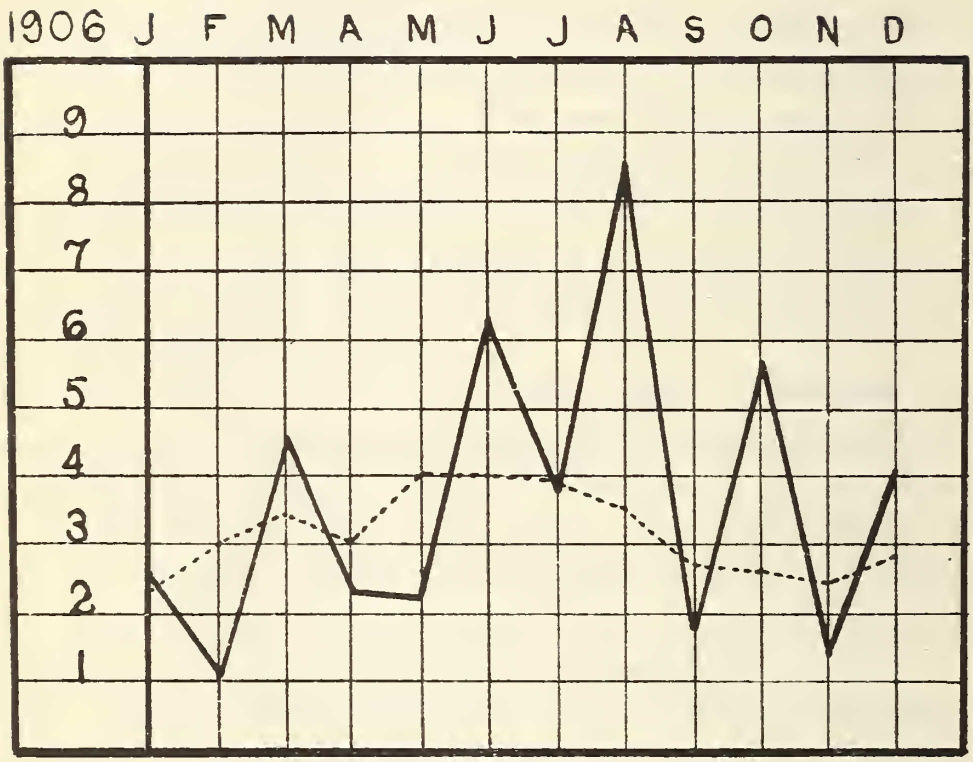
The Potomac, from Fairfax Stone to Great Falls, is 256 miles long, and it averages a fall of 12 feet a mile. As a whole it drains narrow fertile valleys without any lakes to retard the flow, making it subject to frequent floods. Besides the natural shoals and ledges which obstruct the stream, the Chesapeake and Ohio Canal Company has erected dams in order to get water to feed the canal.

There are seven of these dams, each of which is numbered. Dam No. 7 is at Cumberland, No. 6 just above Great Cacapon, No. 5 about 6 miles above Williamsport, Md., No. 4 about in a line from Williamsport to Shepherdstown and about 67 miles above Great Falls, No. 3 at Harpers Ferry, No. 2 half a mile east of Seneca Creek, and No. 1

FIGURE 1

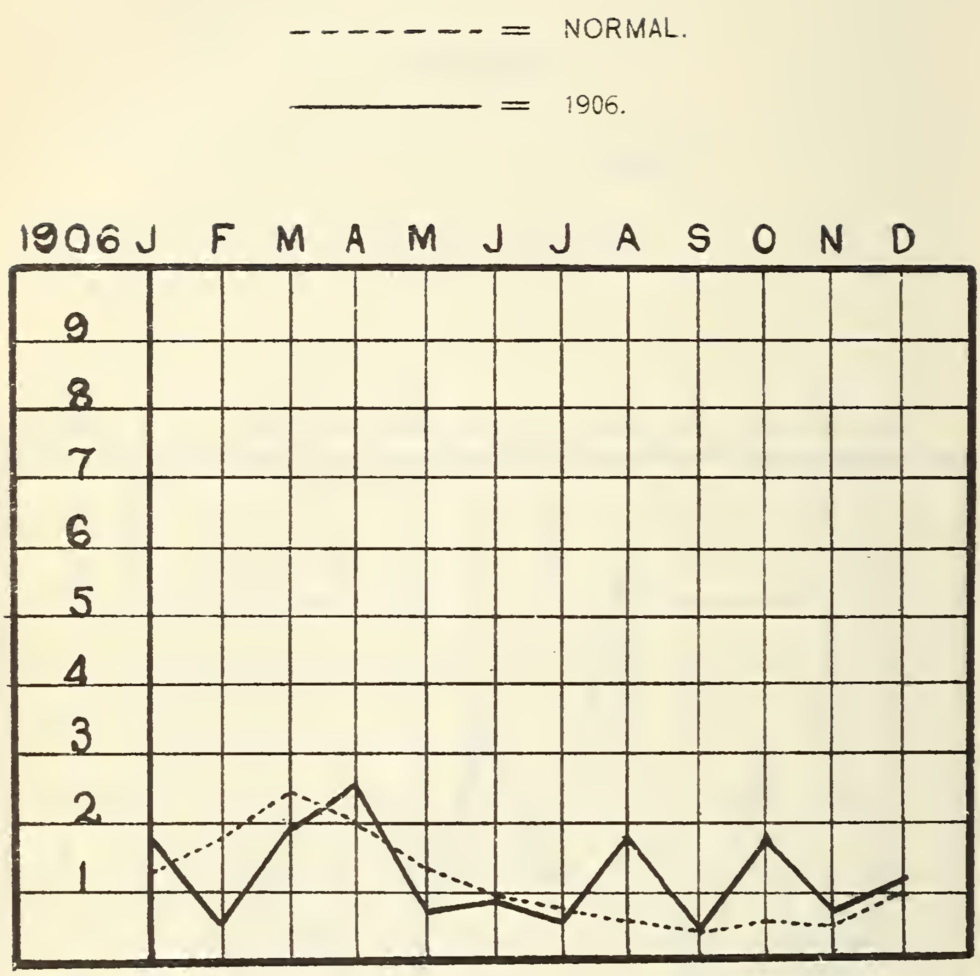
--------- = NORMAL.

———— = 1906.



MONTHLY PRECIPITATION, POTOMAC WATERSHED, IN INCHES.

FIGURE 2.

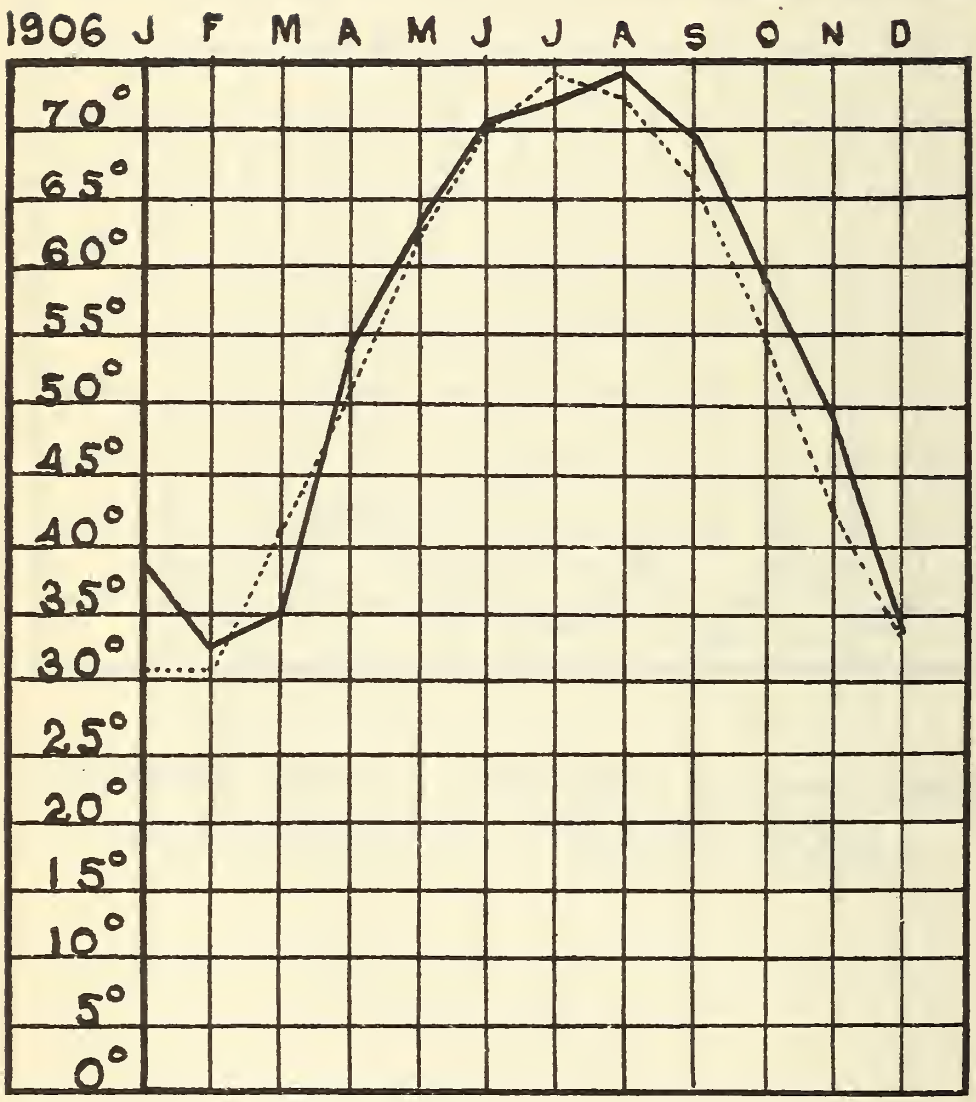


ESTIMATED MONTHLY DISCHARGE, POTOMAC RIVER, POINT OF ROCKS, MD. (DEPTH IN INCHES.)

FIGURE 3.

- - - - - - - = NORMAL.

———————— = 1906.

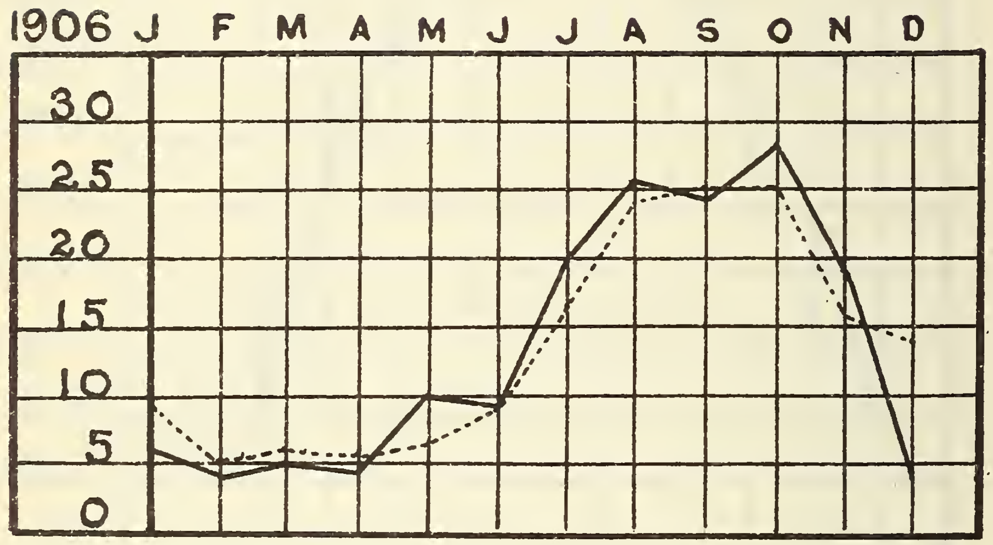


MONTHLY TEMPERATURE, POTOMAC BASIN.

FIGURE 4.

- - - - - - - - = MEAN FOR A PERIOD OF 20 YEARS.

———————— = 1906.



DEATHS FROM TYPHOID FEVER IN THE DISTRICT OF COLUMBIA.

at Little Falls. Depending on their height, they cause slack water, which extends from 4 to 11 miles above each. At Great Falls is a dam above which, on the Maryland side, is the intake of the Washington aqueduct.

The velocity of flow is extremely variable. It has been estimated [a] that it takes from four to seven days for the water to travel from Cumberland to Great Falls, a distance of 176 miles.

The United States Geological Survey has recorded a variation in the volume of discharge of the river at Point of Rocks, Md., ranging from 218,700 to 900 cubic feet a second.

In Table No. 1 is given the monthly run-off for 1906 to September 1, contrasted with the normal, based on data for a period of eleven years.

TABLE NO. 1.—*Showing monthly run-off at Point of Rocks, Md.*

[Drainage area, 9,654 square miles.]

DEPTH IN INCHES.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Normal [a]	1.298	1.848	2.421	2.008	1.350	0.946	0.741	0.651	0.324	0.514	0.419	1.079
Mean, 1906 [b]	1.790	.552	1.900	2.600	.662	.810	.527	1.820	......	......	......	......

CUBIC FEET PER SECOND.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean, 1906	14,990	5,116	15,900	22,440	5,538	7,007	4,406	15,200	......	......	......	......

[a] Calculated from data for eleven years, 1895 to 1905, in Bulletin No. 3, Geological Series, Virginia Department of Agriculture and Immigration.
[b] Obtained from U. S. Geological Survey.

In Table No. 2 is given the mean monthly precipitation, and in Table No. 3 the mean monthly temperature for the Potomac basin from January to September, 1906.

In order to bring out such relation as may exist between the precipitation, run-off, temperature of the Potomac basin, and the prevalence of typhoid in Washington, their curves and that for the typhoid mortality of Washington have been plotted in figures 1, 2, 3, and 4.

TABLE NO. 2.—*Precipitation.*

[Depth in inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Normal	2.54	2.99	3.35	3.00	4.00	4.00	3.96	3.58	2.78	2.70	2.45	2.84
1906	2.66	1.07	4.49	2.42	2.28	6.26	3.88	8.41	......	......	......	......

[a] Captain Gaillard, Annual Report of the Chief of Engineers, U. S. A., 1894, cited in manuscript of the U. S. Geological Survey on the hydrography of the Potomac.

TABLE No. 3.—*Temperature.*

[In degrees, Fahrenheit.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Normal.........	30.7	30.4	41.6	51.0	62.8	70.0	74.6	72.4	66.4	54.7	42.8	33.7
1906.............	37.6	32.5	35.1	53.7	63.0	70.8	72.7	74.3	......	......	......	......

The drainage basin of the Potomac extends into four States—namely, Pennsylvania, Maryland, Virginia, and West Virginia—and at Great Falls measures 11,400 square miles. It is crossed from north to south by a series of parallel ranges, which constitute part of the Allegheny system. In general, the soil in the basin is fertile and is under cultivation. In the mountains cattle raising and lumbering are the chief industries, while in the region of Cumberland enormous quantities of coal are mined every year. Scattered through the basin on the banks of the Potomac and its numerous tributaries are tanneries of varying importance. In the larger towns there are manufacturing industries of various kinds.

The population of this area was estimated in 1900 to be about 500,000, or about 44 per square mile. Of this population about one-sixth is concentrated in places of over 4,000 each. The distribution of the population and its relation to Washington will be best understood by reference to Table No. 4 and the map which accompanies this report.

THE CHESAPEAKE AND OHIO CANAL.

Skirting the Maryland bank of the Potomac from Cumberland to Georgetown is the Chesapeake and Ohio canal. It is built on the surface of the land, but becomes one with the river at two points, namely, for about 3 miles above Dam No. 5 and for about half a mile above Dam No. 4, and is carried over Conococheague Creek and the Monocacy River by two aqueducts. It is about 160 miles long and is constructed for a depth of 6 feet throughout, but varies in width in different sections from 55 to 65 feet at the surface and from 31 to 41 feet at the bottom. The total fall from Cumberland to Georgetown is about 610 feet, broken by 74 locks.

The canal has one intake at Cumberland and is fed at six additional points in its course. It will be remembered that the canal company, to enable it to get water for this purpose, dammed the river at several points. It receives, besides, a few small streams and dry runs, but as a rule all streams pass beneath the canal through masonry culverts directly into the river. To prevent overflow sluices are provided which carry the excess of water directly into the river. At times of flood, however, portions of the canal are under water.

The velocity of flow in the canal varies considerably in different sections, but is assumed to be about 1 mile an hour. A tide lock con-

nects Rock Creek basin at the foot of the canal with the Potomac at that point. The canal season is about eight months long. Its service is discontinued in the winter months after draining off the water.

RAILROADS.

Several important railroad lines are found in the Potomac basin. From east to west there are the Western Maryland and the Baltimore and Ohio railroads. Following the windings of the North Branch down as far as Piedmont, W. Va., is the Western Maryland. At Piedmont it is joined by the Baltimore and Ohio. These two lines of railroad then run side by side as far as Cumberland, where they part, the Western Maryland skirting the north bank as far as Williamsport, Md., where it leaves the river, while the Baltimore and Ohio Railroad follows the south bank to Harpers Ferry, where it crosses to the Maryland side, which it closely follows as far down as Point of Rocks. From north to south the basin is traversed by the Cumberland Valley and the Norfolk and Western railroads, the former crossing the Potomac at Williamsport, Md., and the latter at Shepherdstown, W. Va.

TABLE NO. 4—*Population in Potomac drainage basin.*

PLACES ABOVE 4,000 POPULATION.

Town.	Distance above Great Falls, in miles.[a]	Population (census of 1900).	Town.	Distance above Great Falls, in miles.[a]	Population (census of 1900).
Frederick, Md	47	9,296	Piedmont, Westernport, Luke[b]	207	4,623
Hagerstown, Md	76	13,591	Staunton, Va	223	7,289
Martinsburg, W. Va	86	7,564	Frostburg, Md	224	5,274
Waynesboro, Pa	87	5,396			
Winchester, Va	121	5,161	Total		84,186
Chambersburg, Pa	127	8,864			
Cumberland, Md	176	17,128			

PLACES 1,000 TO 4,000 POPULATION.

Town.	Distance above Great Falls, in miles.[a]	Population (census of 1900).	Town.	Distance above Great Falls, in miles.[a]	Population (census of 1900).
Leesburg, Va	19	1,513	Mount Savage, Md	186	2,000
Brunswick, Md	39	2,471	Hyndman, Pa	190	1,242
Shepherdstown, W. Va	56	1,184	Keyser, W. Va	202	2,536
Charles Town, W. Va	57	2,392	Harrisonburg, Va	211	3,521
Sharpsburg, Md	60	1,030	Barton, Md	213	[a]1,287
Westminster, Md	63	3,199	Lonaconing, Md	216	2,181
Littlestown, Pa	78	1,118	Midland, Md	219	[a]1,800
Williamsport, Md	82	1,472	Ocean, Md	220	[a]1,500
Gettysburg, Pa	83	3,495			
Front Royal, Va	97	1,009	Total		41,445
Greencastle, Pa	104	1,463	Remaining population (rural)		374,567
Woodstock, Va	127	1,069	Towns over 4,000		84,186
Luray, Va	139	1,147			
Shenandoah, Va	165	1,220	Total population		500,198
Eckhart Mines, Md	186	[a]1,600			

[a] From U. S. Geological Survey. [b] These three towns are practically one place.

Population per square mile, 44.

POLLUTION OF THE POTOMAC RIVER.

In considering the character and sources of the pollution of the Potomac attention was given primarily to pollution by sewage. Mention is made incidentally of such industrial pollution as is believed has an important influence on the character of the water.

Starting at the Fairfax Stone and proceeding down the North Branch the first town to merit consideration is Dobbin, W. Va. This town was credited with a population of 581 in 1900. A few of the privies, which are here in general use, directly pollute the river.

Four miles below Dobbin is Bayard, W. Va. This town had a population of 540 in 1900. It is without a public water supply. Buffalo Creek flows through the town and receives some pollution from privies. From the imperfect records available it appears that at least three deaths from typhoid fever occurred here in 1905, showing a probable occurrence of 30 cases during the same period.

Between Harrison, W. Va., and Blaine the river is polluted by some 20 to 25 privies on its edge.

Blaine, situated on both banks of the river, is a town of about 400 population, 1 mile below Harrison. It is without public water supply or sewerage. Private wells and cisterns are in use and latrines are universal, some of which pollute the river and a race which supplies power to a woolen mill. In time of freshet the river scours out a large proportion of the privies in the low-lying part of the town.

Savage River joins its waters with that of the North Branch at Bloomington. Its drainage area of about 348 square miles is but sparsely populated, so that the water, relatively unpolluted and in volume nearly equal to that of the North Branch at this point, dilutes the impurities and so greatly improves the character of the latter.

Luke, Md., is a town that has been built up by the West Virginia Pulp and Paper Company, which employes about 800 men, many of whom come from the neighboring cities of Westernport and Piedmont. Practically all of the sewage created at this point, together with the waste from the factory, goes into the river. The water supply of the town, pumped by the factory, comes from the Savage River and is the same as that of Westernport and Piedmont.

A few cases of typhoid occur annually. One or two cases were present at the time of my visit, though no death due to this disease has been registered in Luke since June, 1904.

One mile below Luke are Westernport, Md., and Piedmont, W. Va. The three towns really form one community, with a combined population of about 5,000. Both Piedmont and Westernport have sewerage systems, that of the former emptying directly into the river, while that of the latter empties into Georges Creek. The two cities have a common public water supply pumped from the Savage River

by the factory at Luke; a change of intake is being made so as to make it a gravity system.

Typhoid fever occurs annually in both towns. The unsatisfactory records obtainable for Piedmont would indicate the occurrence of about ten cases annually there. In Westernport there was a record of one death from this disease in 1903, one in 1904, one in 1905, and one in March, 1906. There was said to be a little more of this disease in both towns this year than in 1905.

Georges Creek joins the North Branch at Westernport. Its waters are badly polluted by drainage from mines. At its head is the town of Frostburg, which is without a sewerage system, so that the pollution of the creek with sewage is indirect.

About midway between Frostburg and Westernport is the mining town of Lonaconing, having a population of 2,181. It has a public water supply derived from two mountain streams, but it has no public sewerage system, though there are some sewers which serve a few houses, stores, and hotels; these sewers empty into Georges Creek, as do many privies which directly overhang the stream.

Some cases of typhoid occur annually. In 1904 three deaths from the disease are recorded, implying an occurrence of about 30 cases of the disease. In 1905 seven deaths were recorded, whereas only one death from this disease has been recorded up to September 15, 1906.

Five miles below Westernport is the city of Keyser. This is an enterprising town having a population of about 2,684. It derives its importance largely from the fact that it is a division point on the Baltimore and Ohio Railroad, which has large shops here. There is also a large woolen mill located at this point. The river here is polluted by the waste from the mill and the sewage of its employees, which directly enter the stream. New Creek, which flows through Keyser and joins the North Branch at this point, receives the sewage of the town. The town is pretty well sewered, although numerous privies are still in use, which probably are responsible for much of the typhoid prevailing here every year; for, although there is a public water supply derived from a near by mountain spring, a considerable number of wells are still in use.

Keyser has a rather unenviable reputation for typhoid. Cases occur every year. In 1904 it had ten deaths from this cause.[a] There has been a good deal of typhoid this year, more than in 1905, but no definite data are available.

From Keyser the North Branch flows on for 26 miles to Cumberland, where it is joined from the north by Wills Creek.

Wills Creek rises on the western slope of Savage Mountain, Somerset County, Pa., and runs northwest to Mance, where it turns and

[a] Public Health Reports, July 20, 1906, p. 843.

flows east to Hyndman. It is polluted by the filth from privies at several minor points before it reaches Hyndman, which is the largest town on the creek.

Hyndman has a public water supply from a near by mountain spring. Privies are in general use; but there is one sewer, which serves a few houses, the bank, and hotels. A tannery on the east side of the creek pollutes the stream with the sewage of its 55 employees. Four or five cases of typhoid were reported this year to September 15.

At Corriganville the creek is joined by Jennings Run, which heads at Frostburg and in its course becomes charged with large quantities of mine water and, at Mount Savage, with the water of Mount Savage Run, bringing its burden of pollution from a fire clay mine and the filth of overhanging privies.

Combined with the waters of Jennings Run, Wills Creek flows on, being joined at the Narrows by Braddock Run, the waters of which are polluted by privies at Eckhart mines and again by large privies at Allegheny Grove, a camping and picnic resort. Recently a tunnel has been completed near Clarysville and the mine water from Eckhart and Hoffman mines, which has heretofore been pumped into Georges Creek, will be diverted into Braddock Run by this route.

Passing through "The Narrows," Wills Creek reaches a dam at the tannery of the United States Leather Company, which diverts more or less of its flow into a mill race, which flows through the city of Cumberland and into the basin of the Chesapeake and Ohio Canal. In times of low water there is no flow over the dam, all the water passing into the race; at other times the excess goes on over the dam and flows through Cumberland to the head of the Chesapeake and Ohio Canal, into which, through the head gates, much of this filth-laden water, more or less mixed with that of the North Branch, passes. Just below this point is Dam No. 7.

The relation that Wills Creek, the mill race, the canal, the river, and Dam No. 7 bear one to the other at this point is of great practical interest to both Cumberland and Washington.

Cumberland, the largest city on the Potomac watershed above Washington, is estimated to have a population of about 20,000. It has a public water supply taken from the river about a mile above where Wills Creek joins it. The water from this intake flows to a well at the pumping station, which is in the park on the river's edge just above the mouth of Wills Creek. The old intake was at this point, but was sealed up when the change to the new was made. It appears, however, that the seal no longer serves its purpose, for when the river is sufficiently high water flows into the well through this intake. Water from private wells and cisterns is used to a considerable extent. A very large part of the city is sewered; the sewers

empty into the river, Wills Creek, the mill race, and the canal basin. The portion of Wills Creek flowing through the city is practically an open sewer; it is overhung by privies and receives much industrial waste.

The slackwater caused by Dam No. 7 becomes in times of drought a practically stagnant crescent-shaped pool, one arm of the crescent being formed by the river and the other by the creek. This circumstance, while favorable to the purification, by sedimentation, of what is practically dilute sewage, can not be other than a matter of grave concern to Cumberland, whose intake, it will be remembered, is only 1 mile above. When the water is so low that none passes over the dam, all the water flows into the canal. It follows, therefore, that at such a time, all the sewage and industrial waste of Cumberland finds its way into the Chesapeake and Ohio Canal.

During the winter, when the water of the canal is drawn off, the race discharges into the basin as usual, but joins the river at the foot of the basin below Dam No. 7.

A good deal of typhoid fever occurs in Cumberland. The record for 1905 was 21 deaths—a mortality of 105 per 100,000. From January 1 to July 1, 1906, there were recorded 11 deaths from typhoid, an increase of 4 over the corresponding period of 1905, as may be seen from the following tabulation.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905	0	2	2	2	0	1	1	1	2	4	5	1
1906	2	2	4	0	1	2	......	......	......	......	......	......

The Chesapeake and Ohio Canal.—The Cumberland basin of the Chesapeake and Ohio Canal, as has been described, is fed by water from Wills Creek and the North Branch, which brings with it much, and at times all, of the sewage of Cumberland, much of which is precipitated at this point as is shown by the fact that the canal company finds it necessary to dredge out the basin about every other spring. This diluted and partly purified sewage flows on down the canal. At Dam No. 6 it is further diluted by the water which is fed to the canal at this point and which is largely water from the South Branch. A half mile above Dam No. 5 and about 88 miles above Great Falls this diluted and more or less purified canal water joins the river. At the dam the canal again takes its separate way to join the river once more about 4½ miles above Dam No. 4, and to be one with it for a distance of about 3 miles. This union takes place about 71 miles above Great Falls. In the rest of its course the canal remains separate from the river, but at each of the dams it takes fresh supplies of

[a] Obtained from Dr. John S. Fulton, secretary State board of health of Maryland.

water, some of which is lost by seepage, and some returns to the river by leakage through the masonry culverts or aqueducts, or at the sluice gates before mentioned. In its course the canal is polluted by the sewage of canal-boat crews and by a few privies of lock keepers and others.

From Dam No. 7 the North Branch flows on to Patterson Depot, where it is joined from the south by Patterson Creek, whose drainage area of about 280 square miles is but sparsely populated. Alaska and Burlington, with a population of about 200 in the former and 300 in the latter, are the largest towns in its valley. Such records as are available indicate that cases of typhoid fever occur at both these points.

Augmented by the waters of Patterson Creek, the North Branch flows on, and 2 miles below Green Spring unites with the South Branch to form the main stream.

The area drained by the South Branch and its tributaries, though exceeding somewhat that drained by the North Branch and its tributaries, has less than one-third the population of the latter and its waters are proportionately even less polluted. Rising in Highland County, Va., it receives its first serious pollution at Franklin, W. Va., the county seat of Pendleton County. Franklin has a public water supply from a mountain spring, but a few wells are also in use. Privies are in general use. There are, however, two private sewers that lead to the bottoms near the river in the neighborhood of which the soil from the privies is deposited, to be washed away by occasional floods.

Cases of typhoid fever occur through the county, though their numbers are few so far as may be inferred from the very unsatisfactory and deficient records available.

About 35 miles below Franklin is Petersburg, W. Va., the county seat of Grant County. It was credited with a population of 312 in 1900. There is no public water supply; wells are depended upon. Privies are in general use, some of which are close to the margin of a mill race, which also receives a private sewer serving one house. All surface drainage of course finds its way either directly or by way of the mill race into the North Branch. Typhoid is of somewhat more frequent occurrence here than at Franklin; a few cases occur every year. This difference may perhaps be in part accounted for by the better water supply at Franklin.

About 12 miles below Petersburg is Moorefield, with a population of 460. It is the county seat of Hardy County, W. Va. It has a public water supply pumped from the Moorefield River above its junction with the South Branch. Privies are in general use, although a sewerage system is being put in which will discharge into the river below the town. No satisfactory data are available for judging the

degree of the prevalence of typhoid, but in conversation with one of the local practitioners I learned that a considerable number of cases occur annually.

The largest town on the South Branch is Romney, W. Va., and it is the only other town to contribute to it any serious pollution. In 1900 it had a population of 580. It is the county seat of Hampshire County, W. Va., and boasts of a public water supply from a mountain spring. It has no sewerage system. A State school for the deaf and blind, having 225 to 250 pupils, is located here; the school has a private sewer which discharges into Big Run, a creek joining the South Branch about a mile below town. The surface drainage of the town is into the river.

A case or two of typhoid occurs in the town every year, said to be, but rarely, of local origin.

Returning to the main stream we reach the town of Paw Paw, about 2 miles below the mouth of the Little Cacapon River. The town is an insignificant one, but has a tannery and is the shipping point for the peach growers of the vicinity. The tannery discharges the sewage of its 140 employees with the waste directly into the river. There is neither public water supply nor sewerage. Being situated on a hillside, the place is naturally well drained, all the surface drainage going, of course, into the river.

A good deal of typhoid occurs here every year, more cases occurring in the country and among the fruit pickers than in the town itself. The occurrence of the disease among the fruit pickers, while of relatively minor importance so far as pollution of the river is concerned, is worthy of consideration in connection with the question of the possibility of the spread of the disease by the fruit, some of which can hardly escape being soiled.

A little below the village of Great Cacapon the Great Cacapon River joins its waters with those of the Potomac. The Great Cacapon is a considerable stream, having a drainage area of 670 square miles, with a population of about 18 to the square mile. There are no towns of importance in its basin.

About 10 miles below, and 108 miles above Great Falls, on the Maryland side, is Hancock. This is a town of about 900 population, and of importance because of the recent advent of the Western Maryland Railroad. It has no public water supply nor sewerage, but two hotels and the railway depot sewer into the river.

Some cases of typhoid occur here every year. Two deaths from this disease have been recorded since January 1 (to September 2), 1906.

Opposite and slightly below Hancock is the Brosius depot, on the line of the Baltimore and Ohio Railroad. Here the waters of Warm Spring Run, polluted at Berkeley Springs, join the Potomac.

Berkeley Springs, the county seat of Morgan County, W. Va., has a population of about 800, which is much augmented during the summer. It takes its water from thermal springs. It has no public sewerage, but the hotels sewer into the run about a half mile below the town.

Scattered cases of typhoid occur throughout the county, and while few, if any, originate in the town itself, the fact of its being the county seat, a summer resort, health resort, and, in other words, a place to which people would go who were suffering from the vague symptoms of the invasion of typhoid, or who were convalescing from the disease and perhaps still discharging the bacilli with their excretions, raises it considerably in importance.

Some miles below Hancock the Chesapeake and Ohio Canal enters and becomes one with the river for a distance of about one-half mile, resuming its separate way at Dam No. 5, 6 miles above Williamsport.

At Williamsport, 82 miles above Great Falls, Conococheague Creek joins the Potomac. Conococheague Creek drains a well-populated area of 580 square miles. It rises in Adams County, Pa., and receives its first important pollution from Chambersburg.

Chambersburg, Pa., a town having a population of 8,864, and removed 127 miles above Great Falls, has a public water supply drawn from the creek, but no sewerage system. Cesspools are in general use, but there are three or four private sewers, which empty into the creek and which serve three or four hotels, the trust company, the court-house, an industrial establishment with 300 employees, some 40 or 50 private dwellings, and a school for girls. Through its little tributary, Falling Spring Run, it receives additional pollution from a steam laundry, from the Cumberland Valley Railroad shops and office building, where there are in all some 300 men; from a shoe factory it receives the sewage of 90 employees. The creek is also polluted by the sewage from the Western Maryland Railroad depot and by the offal of three slaughterhouses.

Some cases of typhoid occur here every year. Ten cases were reported between January 1 and September 1, 1906.

About 20 miles below Chambersburg the creek is joined by a little stream—Moss Bank Run. This stream reaches the eastern part of Greencastle, where its waters sink into the ground apparently to reappear on the town's western edge. In its subterranean course it is probably polluted by the cesspools of the city. The town has a population of 1,463. A water company supplies it with water from two springs 2 miles east of the city.

Five miles below Greencastle the waters of Conococheague Creek are augmented by junction with its west branch, which is polluted at Mercersburg through a little tributary stream.

Mercersburg, Pa., a town with a population of about 1,000, has a public water supply and a sewerage system. The sewerage system consists of two pipes which, with a third pipe from a college having 300 students, discharge into a little town run. Conococheague Creek is next polluted just above its mouth at Williamsport by a large tannery, employing about 250 men.

Williamsport, Md., has a population of about 1,500, but has neither public water supply nor sewerage.

A few cases of typhoid occur here every year. Two deaths from this disease are recorded for 1904, one for 1905, but none for 1906 to August 3.

The Potomac, after receiving Conococheague Creek, flows but 5 miles before it is joined by another important tributary, Opequon Creek. The Opequon drains an area of 335 square miles, most of which is given over to farming, and bears a population of about 25,000, half of which is concentrated in the two cities of Winchester and Martinsburg.

Winchester is the county seat of Frederick County, Va., and in 1900 was credited with a population of 5,161. It has a public water supply from two springs owned and protected by the city. There is no sewerage system; cesspools and privies are in general use. These probably drain themselves through crevices in the underlying limestone into Town Run, which flows through the city to Abrams Creek, a tributary of the Opequon. The run also receives the surface drainage of the city, some kitchen waste, and wastes from a steam laundry and gas house. On July 27 of this year the town was visited by a "cloud-burst," which flooded the streets and cellars and scoured the privies and cesspools.

There are no records to indicate the degree of prevalence of typhoid fever in Winchester and its vicinity. I gathered, however, that there occurs an average of eight or ten cases of the disease every year.

At Jordan Springs, a summer hotel and its cottages discharge their sewage into Lick Run, which joins the Opequon 2 miles below the mouth of Abrams Creek.

Martinsburg is the county seat of Berkeley County, W. Va., and in 1900 was credited with a population of 7,564. It is situated 86 miles above Great Falls, on Tuscarora Creek, 1 mile from its junction with the Opequon. The city has ample supply of water from Patterson Spring, about three-quarters of a mile west of town; a few wells and some cisterns are also in use. There is no sewerage other than for surface water, which goes into a branch of Tuscarora Creek. Cesspools and privies, two or three of which overhang this creek, are in general use. A great deal of industrial waste from woolen mills and gas works is also discharged into the creek.

From the imperfect records available, I estimate that about 30 to 40 cases of typhoid fever occur here every year. Four deaths from this disease are recorded for 1905.

At a point about 1 mile below the mouth of the Opequon the Chesapeake and Ohio Canal, it will be remembered, enters the river a second time and remains one with it for a distance of 3 miles, to resume its separate course about a mile below Dam No. 4.

The Potomac receives its next pollution at Shepherdstown, W. Va., 56 miles above Great Falls. This village, of about 1,200 souls, has no public water supply or sewerage. Cisterns for water are in general use. A small stream which runs through the town, and which is lined with and overhung by privies, serves as a sewer; into it goes the waste from a slaughterhouse. A few cases of typhoid occur in the town and vicinity every year.

Six miles below Shepherdstown the Potomac receives Antietam Creek.

Antietam Creek rises in the Green Ridge Mountains, Franklin County, Pa., and joins the Potomac at a point 58 miles above Great Falls. Its drainage area of about 305 square miles, though somewhat less extensive than that of the Opequon, has almost twice the population of the latter—42,940, according to the census of 1900. The pollution that reaches the creek is mostly indirect; but at Waynesboro, Pa., Hagerstown and Sharpsburg, Md., it receives directly pollution of a dangerous character.

Waynesboro, Pa., with a population in 1900 of 5,396, has a public water supply, but no sewerage. Cesspools are in general use, which take care of themselves by draining through the cracks and fissures in the underlying limestone. The Frick Company, however, runs the sewage of about 700 employees directly into the creek.

Hagerstown, Md., is the third city in the State. It is a rapidly growing industrial center, and was credited with a population of 13,591 in 1900. It has a public water supply from runs on South Mountain, about 10 miles from the city, which is locally regarded as above suspicion.

The comparatively rare cases of typhoid fever which occur here are considered as either imported infections or due to wells, some of which are still in use.

There is no sewerage system in Hagerstown, but there are pipes which are intended only for surface water and kitchen waste, but there is reason for believing that two or three hotels have drains into these pipes from their cesspools. This pollution reaches Antietam Creek by way of Marsh Run, which receives it from Town Run. Cesspools are in general use, many of them being abandoned wells. Most of the cesspools drain themselves through the fissured limestone; the

soil from the others is removed from time to time, and either buried or used for fertilizer.

Typhoid is considered by the physicians of Hagerstown to be a rare disease; but few cases occur annually. I found two deaths recorded for 1905 and two for 1906 to July 25.

Sharpsburg, Md., 60 miles from Great Falls, had a population of 1,030 in 1900. It is near the Antietam battlefield, to which a great many visitors are annually attracted. The town is located on a run which heads at the town spring, from which, together with some wells, is derived the water consumed in the town. The run joins Antietam Creek, and in its course through the town is polluted by several privies.

In 1902 there was an epidemic of typhoid here, and there are three deaths recorded for that year. Since then there has been one death from the disease each year, including 1906, to July 26.

Continuing past the mouth of Antietam Creek, the Potomac flows on to Harpers Ferry, where the Shenandoah unites with it. In its course it receives Elk Branch just above Harpers Ferry. This little stream is polluted by privies at Shenandoah Junction, Duffields, and Keller. These are insignificant villages, and are of importance only from the fact of their proximity to Great Falls.

Harpers Ferry is situated in the acute angle formed at the junction of the Potomac and Shenandoah rivers, 45 miles above Great Falls. It had a population of 896 in 1900. There is no public water supply, springs and cisterns being relied on. There is no sewerage; privies are in common use. A hotel much favored by travelers and excursionists, some private houses, and the railway station discharge their sewage into the river. One of the islands in the Potomac at this point has been made a picnic park; on its edges are two privies which drain directly into the river. Several thousand excursionists visit Harpers Ferry every summer; on the day of my visit (July 26) there were present somewhat over 2,000. No data concerning the presence of typhoid are available. A few cases occur every year, but appear to be relatively more common in the country outside of Harpers Ferry than in the town itself.

The Shenandoah River at Harpers Ferry, drains an area of 3,010 square miles, which had a population of 116,018 in 1900. It is polluted at several points, one of the first of which is almost at the very source of Middle River, which, as will be remembered, is one of the tributaries of the South Fork.

Staunton, Va., credited with a population of 7,289 in 1900, is situated on Lewis Creek, a tributary of Middle River, 223 miles above Great Falls. It has a public water supply derived from springs on the western edge of the town. There is a sewerage system which discharges into Lewis Creek.

No definite records indicating the prevalence of typhoid fever are available. The only index is a hospital, where there have been treated some 18 cases in the fourteen months of its existence, but all of these were said to have acquired their infection out of town.

Basic City and Waynesboro are twin cities situated on the South River. Basic City has a public water supply from a spring; there is no public sewerage, though a large summer hotel and the Chesapeake and Ohio station have a private sewer which discharges into the river. Waynesboro has a public water supply from a spring; there is no public sewerage, but a mill race and a town run are probably directly polluted with sewage.

A few cases of typhoid occur in both towns. Last year there were some 25 cases in Basic City, said to have been traced to an infected well.

Harrisonburg, Va., is the county seat of Rockingham County, and in 1900 had a population of 3,521. It has a public water supply derived from a mountain stream which is locally regarded as above suspicion. It has a combined sewerage system which discharges into Blacks Creek, a branch of Cooks Creek, through which it reaches North River at Mount Crawford.

A few cases of typhoid fever occur in and about Harrisonburg every year, but the disease has become relatively rare since the present water supply was installed.

Luray, Page County, Va., is situated on Hawkbill Creek, a tributary of the South Fork. In 1900 it had a population of 1,147, but this population is much augmented by summer visitors and by excursionists, who come from all parts of the country to visit the wonderful Luray caverns. It has a public water supply, but some wells are still in use. There is no sewerage system, so that privies and cesspools are in general use. One of the hotels and some dozen private houses, however, sewer directly into the creek. The creek is also polluted by a large tannery and by surface drainage, which is rapid on account of the steepness of the slope on which the town is built.

Prior to the introduction of the present water supply a good many cases of typhoid used to occur annually, but now the few cases that occur are generally traced to out-of-town infection or to the use of well water.

About 30 miles below Luray is Front Royal, the county seat of Warren County, Va. Front Royal is on Happy Creek, a small tributary of the South Fork, 97 miles from Great Falls. In 1900 it was credited with a population of 1,005. There is a public water supply from some mountain springs, though some wells and a few cisterns are also in use. There is no sewerage system. The creek is polluted not only by surface drainage but by the sewage from a hotel and two colleges, one of which is converted into a hotel during the summer.

Since the introduction of the water supply there has been a marked reduction in the amount of typhoid which used to occur every year.

Riverton is a small place which lies in the fork of the Shenandoah. The North Fork is polluted here by the drainage from a duck farm and from several privies along its edge. The North Fork has on it several towns from which it receives, however, but little if any serious pollution.

About 25 miles below Riverton the Shenandoah is joined by Lewis Run. On this Run is Berryville, Va., the county seat of Clarke County. Berryville is 75 miles from Great Falls and in 1900 had a population of 938. The town boasts of a public water supply derived from mountain springs. There is no sewerage. The underlying limestone, fissured and seamed, drains the cesspools which, on that account, require no attention. The run is polluted, however, by some nearby privies.

On account of the fine water supply typhoid is said to be of comparatively rare occurrence. It is to be regretted that no data are available showing the degree of reduction in the typhoid rate.

Charlestown, W. Va., the county seat of Jefferson County, is on Evitt Run, a small tributary of the Shenandoah, 57 miles above Great Falls. In 1900 it had a population of 2,392. It has a public water supply from a spring 1 mile from town. A few wells are still in use. There is no sewerage, so cesspools and privies are common; the former, like those in Berryville, drain themselves, while some of the latter are on the edge of the run and drain into it. A few cases of typhoid occur every year. There were more than the average number last fall, but definite figures are unobtainable.

Halltown, W. Va., a small village 57 miles from Great Falls, pollutes Flowing Spring Run, a tributary of the Shenandoah, by some privies on its edge. Typhoid fever appears to be rather prevalent in and about this place.

Leaving Harpers Ferry and proceeding down the Potomac, now augmented by the waters of the Shenandoah, we come in succession to Sandy Hook, Weverton, Knoxville, and Brunswick. Of these, Sandy Hook and Weverton are insignificant in size and would be also in importance but for their situation on the bank of the river and their proximity to Great Falls, from which they are removed 44 and 43 miles, respectively. Privies are in common use and the surface drainage is into the canal and, through small runs, directly into the river.

Typhoid fever is not of rare occurrence.

Knoxville is 1 mile below Weverton. In 1900 it had a population of 363. A creek which runs through the town carries the filth from numerous overhanging privies directly into the river. Some typhoid occurs here every year.

About 2 miles below Knoxville is Brunswick, Md. This is a rapidly growing town on account of the extension of the Baltimore and Ohio Railroad shops and yards which are located here. In 1900 it was credited with a population of 2,471, which is now locally estimated at 4,000. It is about 40 miles above Great Falls, and, to Washington, it is one of the most important points on the Potomac watershed. The water consumed here is from wells, cisterns, and the river, from which it is pumped by the Baltimore and Ohio Railway. There is no sewerage; privies are in general use, some of which drain into and, others, overhang two branches which run through the town. One of these streams also receives the sewage of the railroad bunk house, and will probably receive that of a railroad Young Men's Christian Association building which is being erected.

A good deal of typhoid occurs here every year. From the records for 1904, 1905, and 1906 (to July 28) there appears to be, on the basis of a population of 4,000, an annual mortality from this disease of 50 per 100,000. From January 1 to July 28, 1906, there were reported four cases of the disease.

Proceeding eastward, the Potomac receives in succession Catoctin Creek, Maryland, and Catoctin Creek, Virginia, before reaching Point of Rocks.

In the drainage area of Catoctin Creek, Virginia, there are no centers of population of much importance. Waterford is a village on a small tributary of Catoctin Creek, which is polluted by some privies along and overhanging it. The water consumed is from springs and wells.

A few cases of typhoid are met with in the town of Waterford and surroundings every year.

Washington Junction is the railroad station for Point of Rocks, a small town 33 miles above Great Falls. The depot has water closets which flush into the river and in the village some privies drain into a run which enters the river.

Six miles below Point of Rocks the Monocacy River joins the Potomac. The Monocacy drains an area of 940 square miles, which had a population of 86,661 in 1900. It receives its most serious pollution at Frederick.

Frederick, Md., situated on Carroll Creek, a small tributary of the Monocacy, 47 miles from Great Falls, had a population of 9,296 in 1900. It is the county seat of Frederick County. This town boasts of a fine public water supply which is probably above suspicion. There is no sewerage system, but there are two drains which take the surface water and some domestic waste, soil being excluded. The creek is polluted, however, by the waste and the sewage of 200 employees of the Union Knitting Mill and by the overflow from the cesspool of the woman's college. A few cases of typhoid fever occur

in Frederick every year. During 1906, to July 22, there were two deaths recorded from this disease.

About 10 miles below the Monocacy, Goose Creek joins the Potomac from the south. Goose Creek drains an area of 80 square miles with a population of 13,577 in 1900. This population is pretty generally scattered. Leesburg is the only town of any size within this area.

Leesburg is on Tuscarora Creek, a tributary of Goose Creek, 19 miles above Great Falls. The water supply of the town is from a spring on its western edge and from wells. There is no sewerage system, but there is a drain which discharges its sewage into the creek. The town creek is also polluted by a few overhanging privies. Some cases of typhoid occur here and in the surrounding country every year.

Passing the mouth of Goose Creek, the Potomac receives Broad Run, Sugarland Run, Seneca Creek, Muddy Branch, and Watts Branch before it reaches the Washington dam at Great Falls. The area drained by these small, almost insignificant streams, with about 10,000 population, is given over to farming. The pollution which they get is indirect.

Cases of typhoid occur in and near the small towns along the line of the Baltimore and Ohio Railroad which traverses the northern part of this area, from east to west.

The railroads which traverse the watershed are vehicles of pollution the amount of which it is difficult to estimate. They carry thousands of passengers annually whose excretions are scattered along the lines, which here and there, sometimes for miles, skirt the Potomac and some of its tributaries.

As a general thing the solid excretions do not get into the stream until they are washed there by a rain, so that they are exposed during a variable interval to the influence of light and temperature. This interval may obviously be very short. It is a little different with urine, as some of this may flow in directly and immediately.

PREVALENCE OF TYPHOID FEVER.

In general it may be stated that typhoid occurs from time to time in every part of the watershed. The data available for a study of the degree of its prevalence, however, are extremely unsatisfactory.

In West Virginia the records of vital statistics are very incomplete and defective, while in Virginia there are none at all. Such data as are available have been given above in connection with the locality to which they relate.

Some idea of its seasonal prevalence may, however, be formed from the following table, showing the monthly deaths for 1905 [a]

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[a] Obtained in correspondence from Dr. John S. Fulton, secretary State board of health of Maryland.

from typhoid in five counties of Maryland, which, with the exception of a small part of Garrett and Montgomery, are included in the watershed:

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Allegany	1	3	3	2	1	2	1	2	3	8	10	3
Frederick	3	2	0	0	1	1	2	3	0	1	0	1
Garrett	0	0	2	2	0	2	0	0	0	1	0	1
Montgomery	0	1	0	0	0	1	1	4	2	6	1	0
Washington	1	0	0	0	0	0	0	1	4	1	2	0
Total	5	6	5	4	2	6	4	10	9	20	13	5
Mean (ratio 100)	5.6	6.5	5.6	4.5	2.2	6.5	4.5	11.2	10.1	22.4	14.6	5.6

In the area included in the above table there were recorded a somewhat greater number of deaths during the period January 1 to July 1, 1906,[a] than in the corresponding period last year, as may be seen by comparing the following with the preceding table:

County.	Jan.	Feb.	Mar.	Apr.	May.	June.
Allegany	3	2	5	0	1	2
Frederick	0	1	1	1	0	2
Garrett	0	0	0	1	0	0
Montgomery	0	1	2	1	0	0
Washington	0	0	2	1	9	0
Total	3	4	10	4	10	4

SEWERAGE.

In the description of the sources of pollution mention has been made of the presence or absence of sewerage systems in the several communities considered. It will have been noted that few are sewered, even partially; cesspools and privies, some of which, however, overhang convenient streams, are in very general use.

Of the total population of the watershed it is estimated that not more than 45,000 (9 per cent) contributes direct sewage pollution (see Table No. 5). About 78 per cent of this sewage pollution is at points more than 175 miles from Great Falls, about 17 per cent at points between 50 and 175 miles, and the remaining 5 per cent at points between 19 and 50 miles from Great Falls.

The volume of direct sewage pollution at points within 19 miles of the intake of Great Falls is, in relation to the total, practically nil; but inasmuch as this portion of the watershed is inhabited, pollution of a dangerous character may occasionally find its way into the river from some point or points within this distance of the intake.

[a] Obtained in correspondence from Dr. John S. Fulton, secretary State board of health of Maryland.

The dilution of the sewage at the points where it is discharged is, almost without exception, sufficient to prevent any local nuisance. In its course down the river the dilution increases progressively and by the time it reaches Great Falls it is very great. The degree of this dilution will be clearly comprehended by considering the discharge of the river in relation to the total pollution.

In Table No. 1 is given the mean monthly discharge at Point of Rocks, Md., 33 miles above Great Falls. With 45,000 as the total population contributing direct sewage, the discharge of the river during April was 449 cubic feet a second per 1,000, during May it was 123 cubic feet a second per 1,000, and during June 156 cubic feet a second per 1,000. This dilution would be considerable, even if no change in the character of the pollution during its progress toward Great Falls took place; but when it is considered that conditions such as shoals, rapids, natural pools and dams favoring the processes of purification by aeration and sedimentation are found on the Potomac and its tributaries, and when, in addition, it is remembered that the other factors generally recognized as important agents in the natural process of purification of polluted waters also exist and are probably at work here, the dilution may properly be regarded as, at times, very great.

TABLE No. 5.—*Population of Potomac basin which contributes direct sewage pollution.*

	Distance above Great Falls, in miles.	Population (census 1900).	Estimated population contributing direct sewage pollution.	Per cent of total direct pollution.
(*a*) More than 175 miles above Great Falls:				
Cumberland, Md	176	17,128	17,000	
Keyser, W. Va	202	2,536	2,200	
Piedmont, Westernport, Luke	207	4,623	4,000	
Harrisonburg, Va	211	3,521	2,800	
Staunton, Va	223	7,289	6,000	
Other places			3,000	
Total			35,000	78
(*b*) More than 50 and less than 175 miles above Great Falls:				
Hagerstown, Md	76	13,591	500	
Martinsburg, W. Va	86	7,564	600	
Waynesboro, Pa	87	5,396	1,200	
Winchester, Va	121	5,161	500	
Chambersburg, Pa	127	8,864	1,200	
Other places			3,800	
Total			7,800	17
(c) More than 19 and less than 50 miles above Great Falls:				
Leesburg, Va	19	1,513	200	
Point of Rocks, Md	33	364	150	
Brunswick, Md	39	2,471	450	

TABLE No. 5.—*Population of Potomac basin which contributes direct sewage pollution*—Continued.

	Distance above Great Falls, in miles.	Population (census 1900).	Estimated population contributing direct sewage pollution.	Per cent of total direct pollution.
(*c*) More than 19 and less than 50 miles above Great Falls—Continued.				
Knoxville, Md	41	363	150	
Harper's Ferry, W. Va	45	896	400	
Frederick, Md	47	9,296	500	
Other places			350	
Total			2,200	5
(*d*) Less than 19 miles above Great Falls			000	0
Grand total			45,000	100

SUMMARY OF SANITARY SURVEY OF POTOMAC BASIN.

1. The Potomac River at Great Falls drains an area of about 11,400 square miles.

2. The population of this area was estimated to be, in 1900, about 500,000, or about 44 per square mile.

3. The velocity of flow of the Potomac is extremely variable. It has been estimated that it takes from four to seven days for the water to travel from Cumberland to Great Falls, a distance of about 176 miles.

4. The discharge of the river has been found to vary between 900 and 218,700 cubic feet a second. During April of the present year the estimated discharge exceeded the normal for that month by about 30 per cent; during May the discharge dwindled to 50 per cent of the normal, but rose in June to a point about 12 per cent below the normal.

5. The precipitation was below the normal during both April and May, but was excessive during June.

6. The mean temperature was about 3° F. above normal in April and practically normal during May and June.

7. Typhoid fever prevailed to a greater or less degree in every part of the drainage basin. No data for an accurate determination of the degree or of its seasonal prevalence are obtainable; such as there are indicate strongly that its seasonal prevalence substantially coincides with that of Washington.

8. The waters of the Potomac are directly polluted by sewage at numerous points. This direct pollution is contributed by not more than 45,000 or 9 per cent of the total population on the watershed. Of this pollution, about 80 per cent enters the river at points 176

or more miles from the intake of the Washington Aqueduct at Great Falls, about 15 per cent enters it at points between 50 and 175 miles above Great Falls, and 5 per cent, contributed by about 2,200 of the population, enters at points between 19 and 50 miles above the intake.

9. Practically no direct pollution of the Potomac takes place within 19 miles of the intake; but because this portion of the watershed is inhabited, the possibility of its occurrence can not be ignored.

10. The pollution of the Potomac undergoes more or less natural purification and in addition becomes very greatly diluted before it reaches Great Falls.

BULLETIN 35, HYGIENIC LABORATORY, P. H. & M. H. S.

XI.—TYPHOID FEVER IN WASHINGTON AND ITS RELATION TO THE POTOMAC WATER SUPPLY.

TYPHOID FEVER IN WASHINGTON AND ITS RELATION TO THE POTOMAC WATER SUPPLY.

WASHINGTON'S WATER SUPPLY.

The city of Washington now receives its water supply from the Potomac River. The intake is at Great Falls, about 14 miles above the city. At this point a masonry dam extends across the river from the Maryland to the Virginia side.

From 1859 to 1888 Washington received its water supply from Little Falls Branch, a tributary of the Potomac. A dam was thrown across this little stream about 4½ miles from Washington, forming Dalecarlia reservoir. At the same time (1859) the Georgetown distributing reservoir was put into service.

Dalecarlia reservoir is an unlined storage basin with a capacity of about 150,000,000 gallons, and was originally constructed to collect the surface water from the drainage area of Little Falls Branch. The constant turbidity and impurities introduced from the inhabited watershed draining into the Dalecarlia basin, especially from Tenleytown, led to a discontinuance of this source of supply in 1888, when this reservoir was put out of service and not again used until 1896.

In the meantime the land immediately draining into Dalecarlia reservoir was purchased and controlled, and the waters of Little Falls Branch diverted through a tunnel, and the conduit from the Potomac at Great Falls was connected with the Dalecarlia reservoir, so that in 1896, when Dalecarlia reservoir was again put into service, it received water from the Potomac and not from Little Falls Branch.

The Georgetown reservoir and storage basin has a capacity of about 150,000,000 gallons. It was put into service in 1859, and was used as a distributing reservoir from that date to November, 1905, since when it has served as a settling basin.

The conduit from Great Falls to Georgetown reservoir was completed in 1863, and has furnished the city continuously with Potomac River water from that date to the present time. In order to avoid the impurities from the Little Falls Branch this conduit was built around Dalecarlia reservoir. This section of the conduit now acts as a by-pass, so that whenever the water in the river is clearer than the water in the Dalecarlia reservoir—which not infrequently happens—the by-pass is used and the reservoir closed.

In January, 1902, a third reservoir and sediment basin, known as the Washington City reservoir, having a capacity of about 300,000,000 gallons, was put into service. From 1902 to October, 1905, the city was supplied with water partly from the Washington City reservoir and partly from the Georgetown reservoir, in about the following proportions:

Date.	Average quantity, in million gallons, daily flowing to city from—		Percentage of total supply flowing to city from—	
	Georgetown.	Washington City.	Georgetown.	Washington City.
1902	40	19	68	32
1903	39	22	64	36
1904	34	32	52	48
1905, first half	29	37	44	56
Since October, 1905	0	69	0	100

NOTE.—These figures were furnished by Mr. F. F. Longley, chief chemist of the Washington filtration plant, and were computed from Aqueduct records of elevations in the two reservoirs, and probably are a good indication of relative quantities flowing from the two reservoirs.

The filtration plant was put into complete operation in October, 1905, since which time all the water delivered to the city has been filtered after sedimentation in the three storage basins, viz, Dalecarlia, Georgetown, and Washington City reservoirs.

To recapitulate: From 1859 to 1863 Washington received its water supply from Little Falls Branch, collected in Dalecarlia reservoir and stored and distributed from the Georgetown reservoir.

From 1863 to 1888 the supply was derived partly from Little Falls Branch and Dalecarlia reservoir and partly from the Potomac River taken at Great Falls. From these two sources the water was collected in and distributed from the Georgetown reservoir.

From 1888 to 1895 the Little Falls Branch and Dalecarlia reservoir were not used, and the city received only Potomac River water through the conduit direct to Georgetown distributing reservoir.

From 1896 to January, 1902, the Dalecarlia reservoir, from which Little Falls Branch was now excluded, was again used and the city was given Potomac River water, received in Dalecarlia reservoir and then passed into Georgetown reservoir from which it was distributed.

From January, 1902, to October, 1905, an additional sediment and distributing basin, viz, the Washington City reservoir, was added to this service.

Since October, 1905, the Potomac River water passes through the three subsiding basins, viz, Dalecarlia, Georgetown, and Washington reservoirs, and then through the sand filters. It should be remembered, however, that the Dalecarlia reservoir is sometimes by-passed.

THE WASHINGTON FILTERS.

There are 29 filter beds designed upon the principle of slow sand filtration. Each bed has an effective filter area of 1 acre. The filtered water is collected in a well-protected reservoir of 14,000,000 gallons capacity. The filters and reservoirs for filtered water are built entirely of concrete masonry. They have floors of inverted groined arches on which rest the piers for supporting the groined arch vaulting. These filters contain, on an average, 40 inches of filter sand and 12 inches of gravel graded from coarse to fine, the lower and coarser layer acting as part of the underdrain system, while the upper and finer layer supports the filter sand.

The effluent from one filter was turned into the filtered water reservoir on August 18, 1905, and the other filters were put into service successively at intervals of about two days until October 5, 1905, when a sufficient number were in operation to furnish the entire water supply of Washington. The raw water was then shut off, and from that date to the present time the city has had an uninterrupted supply of filtered water.

The filters are stoutly built and include several ingenious engineering devices. Advantage has been taken of the experience gained by sand filtration in this country and abroad. There are two novel features of the plant, (1) the apparatus for handling the sand and (2) a double drainage system so arranged that the water from each filter can either be wasted into the sewer or returned to the raw-water reservoir.

Slow sand filtration was specified by the act of Congress providing for the plant. The use of a coagulant was prohibited. It was known before the filters were built that slow sand filtration alone would not at all times render the Potomac water clear. Experience has shown this to be correct. The recourse to further treatment, such as increased storage, preliminary filtration, or the occasional use of a coagulant, is still recognized as necessary in order to obtain a satisfactory effluent at all times.

It is too soon to speak of the work done by the filters. So far the results show that they are intelligently managed and have greatly clarified and purified the water. There is no doubt that continued experiments and experience with the special problem at hand will result in still further improvement, especially so far as turbidity is concerned.

We have not made a critical study of the filtration plant and its operation in view of the brief space of time and the limited facilities at hand. The engineer officers of the Army in charge of the plant, and Messrs. Hardy and Longley, in immediate charge of the works, offered us every facility and placed their records at our disposal. To these gentlemen we are indebted for many courtesies. The bacteriological

and chemical methods used in the Hygienic Laboratory and in the laboratory of the filtration plant are practically identical and the results show a general concordance.

No satisfactory explanation has yet been given of the fact that in certain European cities the introduction of sand filtration of a polluted water supply has largely controlled the typhoid fever situation, whereas in America the best that sand filtration has done has been to reduce the death rate to an average of about 20 per 100,000, unless we are willing to admit that the sanitary conditions of our American cities are much worse than those abroad. In such a case the residual typhoid could be accounted for by contacts, imperfect disinfection of discharges, frequent infection of the milk, and an excess of those insanitary conditions known to favor the spread of a "filth disease" such as typhoid fever.

In our opinion, the question of by-passing Dalecarlia reservoir should be seriously considered from a sanitary standpoint. When the water is excessively muddy sedimentation occurs slowly in Dalecarlia reservoir, and as the rise and fall of turbidity in the river itself undergoes sudden variations it not infrequently happens that the water at the intake is clearer than the water in Dalecarlia reservoir. When this condition of affairs exists Dalecarlia reservoir is by-passed, thereby eliminating the well-known good effects of storage and sedimentation in this reservoir. This condition of affairs can be corrected by increasing the storage capacity, so that the water may be shut off at the intake when the river water is excessively turbid.

We can not, however, subscribe to the opinion often expressed that water is necessarily of a good sanitary quality simply because it has been filtered through sand.

The Washington filters have a somewhat different problem to contend with from that of the filters at Hamburg, Albany, Lawrence, and other places where sand filtration has been so successful. The Potomac water differs from these other river waters in that (1) its bacterial content is comparatively low and (2) the suspended matter, consisting of clay, is comparatively high and of peculiar fineness. While the Potomac river water at the intake averages comparatively few bacteria per cubic centimeter it shows great and sudden variations. Furthermore, storage in the three reservoirs effects a destruction of about 55 to 86 per cent of the bacteria contained in the raw water, so that the water actually applied to the filters contains only about 14 to 45 per cent of the original number of bacteria, or 250 to 600 bacteria per cubic centimeter. Slow sand filtration on a large scale, with water containing so few organisms, is a special problem.

It is evident that the interstices between the particles of sand are enormous in size compared with a typhoid bacillus. There must, therefore, be some action in the filter other than mere mechanical straining. Where a "schmutz-decke" is formed it is easy to under-

stand how this gelatinous coat on the surface strains out the bacteria contained in the water. Where this is not formed, as in the Washington filters, we must conceive that the organisms are taken out by some other mechanical, chemical, or biological process. Perhaps the sticky layer which coats each particle of sand forms a gelatinous trap to which the other bacteria adhere and eventually perish. Whatever the explanation, the Washington sand filters actually take out 87.7 to 95.6 per cent of the bacteria in the applied water.

It is well known that bacteria such as the *B. prodigiosus* can pass through a sand filter; also, that such comparatively large particles as yeast cells may do the same. Particles of clay in sufficient numbers to render the water turbid pass through the Washington filters, and it is difficult to see, from a bacteriological standpoint, how the filtering of water through 3 feet of sand without the formation of a "schmutz-decke" can strain out such actively motile organisms as the typhoid bacillus. As a matter of fact, however, the sand filters eliminate a large proportion of the bacteria, both motile and non-motile, contained in the water. Further, sand filtration of other river waters giving a similar reduction of the total bacteria, including the colon bacillus, has been followed by a reduction of typhoid fever.

METHODS USED IN MAKING AND RECORDING BACTERIOLOGICAL EXAMINATIONS OF WATER.

All these examinations were made by Assistant Surgeon A. M. Stimson, United States Public Health and Marine-Hospital Service.

The technique recommended by the committee on standard methods of water analysis of the American Public Health Association on January 9, 1905, was closely followed.

Collection.—The specimens were collected in small ground-glass stoppered bottles protected by tinfoil. The taps or pumps were allowed to run five minutes before the samples were taken and the bottles were filled with the usual bacteriological precautions.

The samples were at once brought to the laboratory and invariably plated within a few hours from the time they were collected. When the delay of an hour or more was necessary after the arrival of a specimen at the laboratory it was placed in the cold room at 15° C. in the meantime.

The following amounts, 0.01 cc., 0.1 cc., and 1 cc., were planted on standard nutrient gelatin, incubated at 20° C. and counted after forty-eight hours.

The following amounts, 0.1 cc., 1 cc., and 10 cc., were planted in lactose broth fermentation tubes and exposed to 40° C. for forty-eight hours, when subcultures were made upon lactose litmus-agar plates from one of the tubes showing fermentation. If more than one of the three fermentation tubes showed gas production, that one was chosen which, from the appearance of the growth and from the

amount of gas, gave the best promise of containing B. coli. The lactose-litmus-agar plates so made were grown at 40° C. over night, and if red colonies appeared a number of them were used to inoculate agar slants. These slants were grown at 37° C. for twenty-four hours and the culture was invariably subjected to further tests, as observation of morphology and motility and reaction on litmus-milk, gelatin, lactose broth, peptone solution, and nitrate solution.

Only those organisms which answered all the tests given in the standard methods of the committee of the American Public Health Association were finally recorded as B. coli. In a few instances organisms answering all the tests except the production of indol are considered B. coli. Such exceptions are noted in each case.

Although three gelatin plates were made containing, respectively, 1 cc., 0.1 cc., and 0.01 cc. of the water to be examined, it was found that the most reliable results were obtained from the plates planted with 1 cc. of the water, and wherever possible this plate was taken as representative of the specimen; but if the plate containing 1 cc. of the water, on account of liquefaction, excessive numbers, or other causes, could not be relied upon, the other two plates containing the smaller amounts were used.

Fermentation in the lactose broth at 40° C. is indicated in the column so headed by a + or − sign. The amount of gas contained in the original fermentation tubes is not given, as it was found to be without significance, B. coli being sometimes found when the tube contained only a bubble and not discovered when a typical one-third to two-thirds of gas was present.

B. coli is reported present in the amounts of water in which it was found, but it was undoubtedly present in smaller amounts in some of the specimens where more than one tube contained gas, as only the one considered most likely to contain the colon bacillus was examined further for that organism. Accordingly such fermentation may be regarded as presumptive evidence of B. coli, but this evidence is not considered in any of the summaries.

Summary of bacteriological examinations of raw and filtered waters.

[July 16 to August 27, 1906.]

	Dalecarlia reservoir.		Georgetown reservoir.	Washington reservoir.	Filtered-water reservoir.
	North end.	South end.			
Number of specimens examined	15	15	15	24	21
Average number of bacteria per cubic centimeter	526	381	306	235	36
Number of specimens	9	12	11	19	16
Percentage showing the B. coli in 1 cc	42.8	40.0	33.3	16.6	4.7
Percentage showing the B coli in 10 cc	28.5	40.0	40.0	41.6	9.5
Total percentage showing the B. coli.	71.3	80.0	73.3	58.2	14.2

Summary of bacteriological examinations of raw and filtered waters—Continued.

DALECARLIA RESERVOIR, NORTH END.

No.	Date.	Number of bacteria in 1 cc.	Fermentation in lactose bouillon. 0.1 cc.	1 cc.	10 cc.	B. coli present in—
						cc.
63	July 30	600	+	+	+	1
95	August 7	?	−	−	+	....
122	August 13	?	+	+	+	1
153	August 20	?	+	+	+	1
160	August 21	?	+	+	+	1
176	August 23	?	+	+	+	1
194	August 27	?	+	+	+	1
230	September 4	1,200	+	+	+	10
246	September 6	540	−	+	+	....
260	September 10	440	−	+	+	10
276	September 13	136	−	−	+	....
289	September 17	220	−	+	+	10
306	September 20	390	....	+	+	....
319	September 24	490	....	+	+	10
336	September 27	720	....	−	+	....

DALECARLIA RESERVOIR, SOUTH END.

No.	Date.	Number of bacteria in 1 cc.	Fermentation in lactose bouillon. 0.1 cc.	1 cc.	10 cc.	B. coli present in—
64	July 30	318	−	−	+	....
96	August 7	?	+	+	+	....
123	August 13	210	+	+	+	1
154	August 20	?	−	+	+	10
161	August 21	300	+	+	+	1
177	August 23	300	−	+	+	10
195	August 27	?	+	+	+	10
231	September 4	1,100	−	+	+	1
247	September 6	800	−	+	+	1
261	September 10	240	−	+	+	10
277	September 13	342	−	+	+	1
290	September 17	360	−	+	+	1
307	September 20	176	−	−	−	....
320	September 24	270	....	+	+	10
337	September 27	159	....	−	+	[a] 10

GEORGETOWN RESERVOIR.

No.	Date.	Number of bacteria in 1 cc.	Fermentation in lactose bouillon. 0.1 cc.	1 cc.	10 cc.	B. coli present in—
65	July 30	338	−	−	+	....
97	August 7	?	+	+	+	0.1
124	August 13	?	−	+	+	10
155	August 20	?	−	−	+	10
162	August 21	200	−	+	+	10
178	August 23	?	−	+	+	1
196	August 24	650	+	+	+	....
234	September 4	320	+	+	+	10
248	September 6	390	−	+	+	1
262	September 10	320	−	+	+	10
278	September 13	104	−	+	+	10
291	September 17	120	−	+	+	....
308	September 20	142	....	−	+	....
521	September 24	150	−	+	+	1
338	September 27	630	+	+	+	1

[a] No indol.

Summary of bacteriological examinations of raw and filtered waters—Continued.

WASHINGTON RESERVOIR.

No.	Date.	Number of bacteria in 1 cc.	Fermentation in lactose bouillon.			B. coli present in—
			0.1 cc.	1 cc.	10 cc.	
						cc.
1	July 16	50	−	−	+	[a] 10
29	July 23	36	−	+	+	1
61	July 30	192	−	−	+	....
93	August 7	?	−	−	−	....
125	August 13	100	−	+	+	1
151	August 20	?	−	+	+	10
165	August 21	?	+	+	+	....
173	August 23	200	−	+	+	1
180	August 24	50	−	−	+	10
188	August 25	?	−	+	+	....
192	August 27	150	−	+	+	10
199	August 28	?	+	−	+	....
206	August 29	470	−	−	+	10
212	August 30	610	+	+	+	....
220	August 31	190	....	....	+	10
228	September 4	420	−	+	+	10
236	September 5	430	−	+	+	....
244	September 6	300	−	+	+	....
263	September 10	570	+	+	+	10
279	September 13	150	−	−	+	....
292	September 17	69	+	+	+	10
309	September 20	1,315	....	+	+	1
322	September 24	80	−	−	+	10
339	September 27	82	−	+	+	....

FILTERED WATER RESERVOIR.

No.	Date.	Number of bacteria in 1 cc.	0.1 cc.	1 cc.	10 cc.	B. coli present in—
42	July 25	33	−	−	−	....
62	July 30	34	−	+	+	....
94	August 7	?	+	+	−	1
126	August 13 [b]	....	....	....	....	....
152	August 20	?	−	−	−	....
166	August 21	?	−	−	−	....
174	August 23	60	−	−	−	....
181	August 24	80	−	−	−	....
189	August 25	?	−	−	−	....
193	August 27	?	−	−	+	10
200	August 28	30	−	−	+	10
207	August 29	32	−	−	−	....
213	August 30	50	−	−	+	....
221	August 31	39	−	−	−	....
229	September 4	34	−	−	−	....
237	September 5	35	−	−	−	....
245	September 6	26	−	−	−	....
264	September 10	33	−	−	+	....
293	September 17	30	−	−	−	....
310	September 20	18	....	−	−	....
323	September 24	24	−	−	−	....
340	September 27	13	−	−	−	....

[a] No indol. [b] Lost.

Summary of the bacteriological examinations of tap water.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Fermentation in lactose broth— 0.1 cc.	1 cc.	10 cc.	B. coli in—
		1906.					cc.
2	1112 Tenth street NW	July 16	200	–	–	–	....
4	3 F street NW	....do ...	60	–	–	–	....
7	1523 Seventh street NW	July 17	23	–	–	–	....
10	811 Thirteenth street NW	....do ...	90	–	–	+	10
12	25 Defrees street NW	July 18	74	–	–	+	10
16	1706 Twelfth street NW	....do ...	40	–	–	+	10
19	Facing 442 N street NW. (hydrant)	July 19	54	–	+	+	....
20	448 O street NW. (alley)	....do ...	75	–	–	+	....
22	2 Thomas circle NW	....do ...	40	–	–	+	[a] 10
25	643½ Third street NE	July 20	22	–	–	–	....
27	516 D street NE	....do ...	72	–	–	+	....
31	909 Fourth street SE	July 23	189	–	–	+	[a] 10
33	607 E street SE	....do ...	64	–	–	+	....
39	115 Eleventh street NE	July 24	33	–	–	–	....
41	235 C street SW	....do ...	58	–	–	–	....
43	1521 Thirty-fifth street NW	July 25	42	–	–	+	....
47	2900 P street NW	....do ...	42	–	–	+	10
49	20 Seventh street SE	July 26	33	–	–	–	....
50	808 East Capitol street	....do ...	23	–	–	–	....
51	537 Kentucky avenue SE	....do ...	21	–	–	–	....
52	415 Delaware avenue SW	....do ...	16	–	–	+	10
54	1003 E street SW	....do ...	50	–	–	+	10
55	1215 Potomac street NW	July 27	25	–	–	+	10
56	1302 Thirty-sixth street NW	....do ...	31	–	–	–	....
59	1522 Twenty-sixth street NW	....do ...	30	–	–	–	....
60	2814 Pennsylvania avenue NW	....do ...	34	–	–	–	....
66	1432 Thirty-sixth street NW	July 31	684	+	+	+	1
68	1301 Thirtieth street NW	....do ...	24	–	–	–	....
69	1243 Thirtieth street NW	....do ...	37	–	–	–	....
70	1023 Twenty-sixth street NW	....do ...	38	–	–	–	....
73	412 L street NW	Aug. 1	49	–	–	–	....
74	1906 Eleventh street NW	....do ...	55	–	–	+	....
75	1118 Union court NW. (hydrant)	....do ...	125	–	–	+	10
76	2125 L street NW	....do ...	34	–	–	+	....
78	1667 Euclid street NW	Aug. 2	36	–	–	–	....
79	1872 V street NW	....do ...	22	–	–	–	....
80	2148 Florida avenue NW	....do ...	57	–	–	–	....
81	2142 K street NW	....do ...	39	–	–	–	....
82	1249 Twenty-ninth street NW	Aug. 3	51	–	–	+	....
83	3267 N street NW	....do ...	18	–	–	–	....
84	3616 P street NW	....do ...	41	–	–	+	....
85	1511 Thirty-fourth street NW	....do ...	237	–	+	+	1
86	2820 P street NW	....do ...	32	–	–	+	....
87	1432 Thirty-sixth street NW. (hydrant)	....do ...	88	–	+	+	10
90	1621 Minnesota avenue, Anacostia	Aug. 6	24	–	–	–	....
98	3284 N street NW	Aug. 7	?	–	–	–	....
99	3207 P street NW	....do ...	?	–	–	–	....
100	2812 Pensylvania avenue NW	....do ...	?	–	–	–	....
118	732 Eighth street NW	Aug. 10	28	–	–	–	....
119	414 Twenty-first street NW	....do ...	54	–	–	+	....

[a] No indol.

Summary of the bacteriological examinations of tap water—Continued.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Fermentation in lactose broth— 0.1 cc.	1 cc.	10 cc.	B. coli in—
		1906.					cc.
132	1716 Thirteenth street NW	Aug. 14	10?	−	−	+	....
137	641 H street NE	Aug. 15	?	−	−	−	....
142	234 Thirteenth street NE	Aug. 16	?	−	−	−	....
149	313 Seventh street SE	Aug. 17	?	−	−	−	....
150	421 Fifteen-and-a-half street SE	....do...	370?	−	−	−	....
156	1220 Banks street NW	Aug. 20	?	−	−	+	10
157	3405 Q street NW	....do...	?	−	−	−	....
163	1927 G street NW	Aug. 21	80	−	−	+	....
164	519 Twenty-second street NW	....do...	?	−	−	+	10
172	708 Tenth street NW	Aug. 22	?	−	−	−	....
179	3102 M street NW	Aug. 23	100?	−	−	−	....
187	477 F street SW	Aug. 24	9?	−	−	−	....
190	623 Maryland avenue SW	Aug. 25	?	−	−	−	....
191	911 Four-and-a-half street SW	....do...	?	−	−	+	10
197	3535 O street NW	Aug. 27	10?	−	−	+	....
198	3624 O street NW	....do...	100	−	−	+	10
205	2008 F street NW	Aug. 28	?	−	−	+	....
210	633 K street SE	Aug. 29	30	−	+	−	....
211	235 Thirteenth street SW	....do...	37	−	−	+	10
216	654 Morton street NE	Aug. 30	22	−	−	−	....
219	207 Tenth street NE	....do...	14	−	+	−	....
222	72 Bates street NW	Aug. 31	33	−	−	−	....
223	16 T street NW	....do...	16	−	−	−	....
242	807½ I street NW	Sept. 5	44	−	−	−	....
243	532 Twenty-third street NW	....do...	50	−	−	−	....
249	3415 Volta place NW	Sept. 6	50	−	−	−	....
250	1678 Thirty-first street NW	....do...	32	−	−	+	....
259	1218 D street NE	Sept. 7	51	−	−	−	....
269	621 Seventh street NW	Sept. 11	40	−	−	−	....
270	919 Virginia avenue SW	....do...	370	−	+	+	10
274	624 Third street NW	Sept. 12	23	−	−	−	....
275	903 New Hampshire avenue NW	....do...	27	−	+	−	....
281	3059 M street NW	Sept. 13	36	−	−	−	....
282	2805 Dumbarton avenue NW	....do...	28	−	−	−	....
283	731 Twenty-second street NW	Sept. 14	?	−	−	−	....
284	5 Iowa circle NW	....do...	?	−	−	−	....
285	21 Sixth street NE	....do...	41	−	−	−	....
286	729 H street NW	....do...	?	−	−	+	....
287	1530 O street NW	....do...	53	−	+	−	....
294	Toner School, Twenty-fourth and F streets NW	Sept. 17	24	−	−	−	....
296	Corby Co., boiler room, Langdon	Sept. 18	29	−	−	−	....
297	Corby Co., vinegar house, Langdon	....do...	12	−	−	−	....
298	3830 Brightwood avenue	....do...	60	−	+	+	10
299	1531 Marion street NW	....do...	18	−	−	+	....
301	28 Adams street, Anacostia	Sept. 19	25	−	+	+	....
302	10 Maple avenue, Anacostia	....do...	35	−	−	−	....
303	Frazier's Coal Yard	....do...	31	−	−	−	....
304	Seventh street and Virginia avenue SE	....do...	16	+	−	−	....
305	Seventh street and Pennsylvania avenue NW. (public fountain)	....do...	14	−	−	+	10
312	3214 Q street NW	Sept. 20	23	−	−	−	....
313	1803 G street NW	....do...	21	−	−	−	....

Summary of the bacteriological examinations of tap water—Continued.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Fermentation in lactose broth— 0.1 cc.	1 cc.	10 cc.	B. coli in—
		1906.					*cc.*
317	3329 Brightwood avenue	Sept. 21	26	–	–	+	10
318	2458 Eighth street NW	....do ...	26	–	–	–	....
324	Western High School	Sept. 24	33	–	+	+	....
325	Peabody Library	....do ...	39	–	–	+	....
327	1014 F street NE	Sept. 25	21	–	–	–	....
328	1117 V street NW	....do ...	66	–	+	–	....
335	1622 Thirty-second street NW. (hydrant)	Sept. 26	1,365	+	+	+	....
341	1476 Newton street NW	Sept. 27	23	–	–	+	....
342	1506 Meridian place NW	....do ...	76	–	–	–	....
344	Bruce Colored School	Sept. 28	144	–	–	–	....
345	School Tenth and N streets NW	....do ...	27	–	–	–	....
346	Business High School	....do ...	29	–	–	–	....
347	Garrison School	....do ...	28	–	–	–	....
348	Iowa Circle NW. (public fountain)	....do ...	63	–	–	–	....
349	Sumner School	....do ...	50	–	–	–	....
350	Stevens School	....do ...	11	–	–	–	....
351	2414 K street NW	Oct. 1	9	–	–	–	....
352	714 Twenty-third street NW	....do ...	15	–	–	–	....
353	1391 F street NE	Oct. 2	10	–	–	–	....
354	68 I street NW	....do ...	8	–	–	+	....
355	1221 New Jersey avenue NW	Oct. 3	18	....	–	–	....
356	Fire department B, New Hampshire avenue and N street	....do ...	16	....	–	–	....
379	Twelfth and N streets NW	Oct. 6	11	–	–	–	....
380	Twenty-third and H streets NW	....do ..	17	–	–	–	....
408	Ninth and Michigan avenue	Oct. 9	10	....	–	–	....
419	Second and G streets NE	Oct. 10	30	....	–	–	....
428	Pennsylvania avenue and F street SE	Oct. 11	17	....	–	–(a)	....
453	Twelfth and M streets NW	Oct. 15	40	–	....	....	....
459	First and B streets SE	Oct. 16	72	....	–	–	....

[a] 5 cc. in 10 cc. column.

A study of our tables will show that we made daily bacteriological examinations of several samples of the tap water, collected as a rule from houses in which cases of typhoid fever had occurred. We could not, however, make a daily study of the successive changes in the river water as it passed through the three subsiding basins, the filters and the storage reservoir, on account of the distance of the water system from our laboratory and the press of other matters. All the data we have, however, bearing upon this important question are given.

Our results show that the great majority of the bacteria contained in the raw water are removed by sedimentation, storage and filtration. During the period studied by us the filtered water in the filtered water reservoirs averaged 36 bacteria per cubic centimeter (maximum 80, minimum 13). The water as it runs from the taps

contains a few more organisms (average 64 per cubic centimeter) than the effluent from the filters.

Our data upon the number of bacteria found in the raw water is too limited to give the percentage reduction. Taking the figures of the filtration laboratory for the same period, viz, average 7,619 bacteria per cubic centimeter in the raw water, we have 99.2 per cent removed by the entire water system.

Our limited studies confirm the fact that a large number of bacteria are eliminated in the storage and subsiding basins, as well as in the sand filters.

As far as the colon bacillus is concerned, some of them pass the filters and survive in the water as it is collected in the filtered water reservoirs and as it runs from the taps. The number of samples of tap water containing the colon bacillus diminished from the last of July throughout the remaining period during which these tests were made (see p. 27).

Fifteen and two-tenths per cent of the samples of tap water examined contained the colon bacillus in 10 cc., 2.2 per cent in 1 cc., making a total of 17.5 per cent of the samples of tap water examined.

The raw water, according to our studies, contained the colon bacillus in 71.7 per cent of the samples examined. Sixty-nine per cent of the raw water samples examined during the same period at the laboratory of the filtration plant contained the colon bacillus.

This gives an approximate reduction of about 77 per cent of the colon bacilli in the river water by storage and filtration.

THE MUD IN THE WATER PIPES.

The suggestion has been advanced by some that the large amount of mud contained in the pipes of the water system retains the typhoid infection, this being distributed throughout the city. From our knowledge of the viability of the typhoid bacillus, we should think this to be unlikely, and a few experiments confirmed this opinion. Some of this mud was placed in ordinary 1-inch iron pipes, sterilized, and then abundantly planted with typhoid cultures. Two pipes thus prepared, containing the typhoid infected mud, were kept, one at room temperature and one at 15° C. It was found that the organisms were still alive at the end of thirty days but dead at the end of two months.

THE BACTERIOLOGICAL STUDIES OF POTOMAC WATER IN PREVIOUS YEARS.

It is interesting to compare these results with the work of others upon the bacterial content of Potomac water in previous years.

In 1897 and 1898 extensive analyses of the Potomac River water were made in the Hygienic Laboratory, United States Public Health

and Marine-Hospital Service, and reported by Dr. J. J. Kinyoun, then director of the Laboratory, in the Annual Report of the Supervising Surgeon-General for 1898. Passed Assistant Surgeon E. K. Sprague conducted the bacteriological examinations, which consisted of semi-weekly analyses from a constantly flowing tap from July 1, 1897, to February 28, 1898. The following table gives the quantitative results:

Number of bacteria found in Potomac water at each examination.

Date.	Aerobic bacteria found in 1 cubic centimeter.	Anaerobic bacteria in 1 cubic centimeter.	Date.	Aerobic bacteria found in 1 cubic centimeter.	Anaerobic bacteria in 1 cubic centimeter.
1897.			1897.		
July 1	650	Count not made.	Nov. 1	17	50
6	400	100	4	167	33
9	4,600	2,800	8	733	117
12	366	33	11	183	133
15	33	66	15	250	83
19	266	400	18	317	117
22	200	66	22	100	83
26	166	66	25	466	216
29	? 150	? 100	28	833	1,000
31	466	116	Dec. 2	2,267	1,200
Aug. 2	316	100	6	4,300	300
5	183	66	9	900	600
9	216	116	13	700	533
12	133	83	16	1,200	366
16	300	33	20	933	433
19	100	200	23	1,200	300
23	283	433	27	367	Count not made.
26	250	66	30	283	Do.
30	166	300	1898.		
Sept. 2	366	133	Jan. 3	No growth.	67
6	116	116	6	533	100
9	2,200	1,200	10	567	167
13	150	200	13	500	200
16	50	500	17	566	66
23	150	16	20	467	233
27	150	100	24	700	400
30	200	0	27	733	167
Oct. 4	16	50	31	433	566
7	33	33	Feb. 3	400	400
11	116	83	7	633	66
14	83	50	10	167	87
18	216	100	14	166	200
21	83	50	17	333	33
25	33	50	21	333	66
28	167	50	24	1,133	166
			28	1,000	533

It will be seen from this table that the largest number of bacteria occur in Potomac River water during the winter and spring months. It is therefore evident that typhoid fever is most prevalent in Washington while the number of bacteria in the river water is lowest, and vice

versa. On the other hand, Doctor Sprague showed that the colon bacillus occurs in the greatest numbers in the Potomac River water during the months of September and October, and attention is called to the parallelism existing between the death rate from typhoid fever and the percentage of times the colon bacillus was found.

Percentage of times colon bacilli were found in Potomac water.

	Per cent of examination present.
1897.	
July	30
August	33⅓
September	70
October	70
November	40
December	20
1898.	
January	20
February	25

Doctor Sprague states:

That during the heated season the bacteria should be few is natural and easy of explanation. The anaerobic bacteria are at this time present in much greater numbers in proportion to the aerobic than at any other season of the year. Now, in as much as the anaerobes indicate with a fair degree of accuracy the amount of sewage contamination, it is evident that from August to November the Potomac River is more dangerously polluted than at any other season of the year. That there should be this relatively increased number of sewage organisms is equally as readily explained as that the total number of bacteria should be low. During the late summer and early autumn there is low rainfall, consequently few organisms are washed into the river from the surface of the earth, the source of by far the greater part of the bacteria present in water.

During the season, however, the quantity of house sewage is appreciably above the yearly average, and it is from this source that the bacteria must come: hence we have a relative increase of the dangerous bacteria and a dimunition of the nonpathogenic varieties. At first glance it would appear that the highest typhoid death rate with the fewest organisms was contradictory, but when all the circumstances are taken into consideration it is at once seen that, so far from being a contradictory state of affairs, it is exactly what is to be expected. That the typhoid death rate, the presence of colon bacilli, the fermentation changes in the media and the temperature should coincide with one another is perfectly logical, and there is but one conclusion that can be drawn therefrom—the increased mortality from typhoid and diarrheal diseases is due to the increased quantity of bacteria from the intestines of man, which our citizens are compelled to digest at that time. The causal relation between impure drinking water and this death rate is so evident to my mind that it is almost a criminal negligence to allow such an easily preventable condition of affairs to longer obtain in our midst, and it can be truthfully said that just so long as the inhabitants of this District are compelled to use Potomac water in its present state of pollution from 200 to 250 lives will be needlessly sacrificed annually.

The following is a summary of the number of bacilli present in 1 cc. of raw Potomac water, taken from the report of Lieut. Col. A. M. Miller, Corps of Engineers, U. S. Army, in Senate Document No. 259, Fifty-sixth Congress, first session, 1900:

Date.	Maximum.	Minimum.	Average.
1899.			
July (19 days)	790	48	154
August	685	67	269
September	556	90	196
October	500	80	138
November	1,200	70	401
December	31,000	135	3,281
1900.			
January	51,000	3,500	15,700
February	26,200	2,500	9,950

Colonel Miller says that—

The bacteriological results obtained show that the Potomac water as delivered from the mains is, in times of turbidity and low temperature, dangerous to health by reason of the quantity of bacteria present.

Fifty per cent of the specimens examined, or one-half, indicated the presence of the colon bacillus, from which Colonel Miller concluded that the water supply of Washington was dangerous to health and required filtration.

Theobald Smith made a study of the quantitative variations in the germ life of Potomac water during the year 1886.[a] The water for these analyses was drawn from a faucet in the basement of the Department of Agriculture which was contantly in use, so there could have been no stagnation of the water in the smaller pipes.

As to the results of these observations, we first observe that the number is highest in winter, in spite of the fact that the heat greatly favors and cold checks multiplication.

[a] Medical News, vol. 50, April 9, 1887, p. 404.

Table giving the monthly average number of bacteria found in 1 cc. of Potomac drinking water during 1886.

	Number of observations.	Average.	Rain fall (inches).
1886.			
January	2	3.774	3.46
February	4	2.536	2.79
March	5	1.210	4.16
April	4	1.521	4.21
May	3	1.069	7.77
June	2	348	4.98
July	2	255	8.42
August	1	254	1.03
September	2	178	1.04
October	3	75	2.31
November	1	116	3.69
December	2	967	3.07
1887.			
January	3	882	2.19

"This anomalous condition is not so difficult of explanation. In the winter the water as it reaches the city is more or less turbid, and, when shaken, clouds, composed of very minute particles, are seen. These will pass through ordinary filter paper, and when gathered together as in distilling water the residue is made up of reddish earth. This turbidity, most pronounced in winter, gradually disappears toward summer, when the water becomes very clear and limpid. The number of bacteria varied with the change in turbidity, being highest when the suspended matter was most abundant. This fact impressed me so strongly after a number of observations that it became possible to anticipate quite accurately the number of bacteria present by looking at the water in the tube with the transmitted light."

"It seemed reasonable to conclude that whatever agency brought the suspended earth also brought the bacteria and that the earth contained the bacteria. Throughout the winter of 1886 I noticed that after heavy rains the turbidity increased quite suddenly, this fluctuation, of course, producing a corresponding rise and fall in the number of bacteria. The rain, washing down the soil from the surface drained by the tributaries of the river, was thus the cause of the turbidity. But was there any relation between the rainfall and the number of bacteria? Through the kindness of the signal officer I obtained the data given in the third column of the table. Comparing the second and third columns, the relation is certainly not on the surface. The heaviest rains occurred in July, but the number of bacteria did not rise perceptibly and no turbidity appeared. The only explanation which suggests itself is that which must be sought

in the changed condition of the surface of the soil in winter and summer as regards vegetation. The precipitated water is caught by the foliage of trees, by the grass and herbage, which clothes the soil everywhere. The soil itself is at the same time more firmly bound together by the vegetation itself. In winter all this is changed. The absence of vegetation leaves the loose soil ready to be washed into streams by rain and melting snow, carrying with it the bacterial vegetation."

"The majority of bacteria carried into the river are, no doubt, harmless, but what is to prevent the infectious micro-organisms of typhoid and other diseases from being washed down and being carried into our houses with the suspended matter? The danger in this is not constant but only occasional. The number of bacteria may have no direct significance, but it is certainly an index of the possible danger. It is safe to assume that Potomac water free from suspended matter contains from 50 to 200 bacteria in 1 cc. This will, no doubt, be found a low average for unfiltered water when more statistics have been collected for other streams whose water is used to supply towns and larger cities."

No qualitative examination of the different kinds of bacteria was made for want of time.

The report of the Committee of the District Medical Society on typhoid fever in the District of Columbia (1894) states (p. 8.):

As the result of one year's observation made by Theobald Smith, a relation was found between turbidity and the presence of bacteria. Bacteria were most abundant in winter, January and February having the highest average; August, September, and October, the months of the greatest prevalence of typhoid fever, having the lowest. Bacteria, most of which are harmless, were most abundant after heavy rains, and their presence in association with turbidity proved the then source to be from the washing of the surface of the soil.

In the latest bacteriological report on Potomac water Theobald Smith adheres to this statement, and says that fecal bacteria and turbidity were coincident; that is, that rainfall carries into the Potomac whatever may happen to be on the surface of the soil—clay, manure from the fields, inorganic or organic matter of any sort. The nature of the country through which the Potomac flows, much of it being mountainous, as well as the absence of large cities on its banks, diminish the risks of infection from this source. As the country comes more and more under cultivation turbidity and impurity from the washing of plowed and manure-covered land will be more common. The possibility of the introduction into the water of the micro-organism of typhoid fever is dependent upon its presence in localities washed by the Potomac and its tributaries.

29643—07——18

XII.—THE CHEMICAL EXAMINATION OF THE WATER SUPPLY OF THE DISTRICT OF COLUMBIA.

CHEMICAL EXAMINATION OF THE WATER SUPPLY OF THE DISTRICT OF COLUMBIA.

It must certainly be admitted in the light of our present knowledge that, as a general thing, the cause or causes of typhoid fever in any community lie beyond the reach of chemical investigation. Indeed, it is doubtful whether in all instances the more remote causes of the disease are even within the immediate scope of bacteriology, for the reason that owing to the time which must necessarily elapse between the recognition of the disease in the individual and the time of infection the immediate source of the infection may have ceased to exist, so that we are of the opinion, so ably advanced by Professor Sedgwick,[a] that it frequently happens that the cause or causes of such diseases as typhoid which have become endemic are to be sought for, not only in the laboratory, but in the community at large, through the study and comparison of sanitary statistics, which, in many cases at least, represent results and data covering long periods of time.

On the other hand, it occasionally happens, as recently pointed out by Professor Mason,[b] that in some instances at least, notably in the case of certain well waters, the danger signal of a serious condition of pollution has been held out by the chemical side of the investigation alone, and while, as he puts it, bacteriology deals with the present, chemistry, in the case of a natural water, deals with the past, and may occasionally, at least, throw some light on the future in so far as pollution or infection is concerned.

It should be borne in mind, however, that among others who have done a very great amount of work in this field, and whose opinions are in every way entitled to respect, there are some who are inclined to question the value of a sanitary water analysis, and, as has recently been pointed out by Leighton[c] in criticism of the case

[a] See address delivered before Section K of the American Association for the Advancement of Science, New Orleans, December, 1905. Science, New Series, Vol. XXIII, No. 584, pp. 362–367.

[b] "Interpretation of a Water Examination," by W. P. Mason. Science, New Series, Vol. XXI, No. 539, pp. 644–653.

[c] See "The Futility of a Sanitary Water Analysis as a Test of Potability," by Marshall O. Leighton, in Biological Studies by the Pupils of William Thompson Sedgwick, Boston, 1906, pp. 36–53.

cited by Mason, the "danger signal" of the pollution of this particular well under discussion was first discovered, not in the findings of the chemical analysis, as held by Mason, but in the occurrence of disease in this particular residence and in the fact that on these premises a "dry-steyned" cesspool and a shallow well were "both sunk in gravel" at the short distance of only 4 yards apart. While it is well to bear in mind the present unsettled condition of opinion which prevails on the subject of sanitary water analysis and which in itself is no new thing, it is not a part of the problem before us to enter into any discussion of these conflicting views, but simply to make such use as we can of chemical analysis as one of the several means to the end of arriving at the cause of typhoid fever in the District of Columbia.

Our present inquiry, therefore, has included the chemical examination or sanitary analysis of the principal kinds of water used for drinking purposes in the District of Columbia. Broadly, the several kinds of water used for drinking purposes in this locality may be classified as follows:

First, the filtered water of the Potomac River, which is used for drinking purposes by certainly the greater number of the inhabitants of Washington and the District of Columbia; secondly, the waters of 24 deep and 63 shallow public wells, distributed over a comparatively large area, but located in largest number in the northwest portion of the city, the waters of which are used for drinking purposes by a considerable number of persons; and thirdly, a number of so-called table or bottled waters, including distilled water, manufactured here and elsewhere, and of which a considerable number are used for drinking purposes among the wealthier classes, but which obviously are used by a fewer number of persons. Our study has also included the chemical examination of the local water supplies of certain institutions and communities, such as that of the Government Hospital for the Insane, Soldiers' Home, and Chevy Chase. We have also examined a number of samples of ice, sold and manufactured in the city, and a number of wells used in connection with ice plants, either for the manufacture of ice or for the purposes of mechanical cooling and condensation, or both.

METHODS OF ANALYSIS.

So far as practicable, we have followed the standard methods of water analysis recommended by the committee on standard methods of water analysis of the American Public Health Association, which are set forth in detail in their final report published in Supplement No. 1, May, 1905, of the Journal of Infectious Diseases. Our examination included, in most instances at least, the determination of total solids, chlorine, free and albuminoid ammonia, nitrites, nitrates,

dissolved oxygen, and oxygen consumed, together with the physical characteristics of the water, such as color, odor, turbidity, and sediment. In the time at our disposal, and for other reasons, it has not been found possible in all cases to determine the color and turbidity in terms of the standards now in use for these purposes. However, in all cases the best general description possible has been given of the several samples of water analyzed, and in all cases in which it has been found possible to do so comparison has been made with the fixed standards for color and turbidity, and in our tables the numbers obtained have been placed alongside of the general description of the water. The waters of the shallow wells were found to be so clear and colorless as to render these determinations unnecessary, and on account of the iron which they contained the waters of the deep wells altered so much in color and turbidity on standing after the sample had been collected that such determinations are without significance. Except in the determination of total solids, the several determinations on all samples of water were begun as soon as the sample was brought into the laboratory and completed the same day as collected, so that at most only a few hours elapsed between the collection of the sample and the completion of the chemical examination thereof. The determination of total solids, including the total residue on evaporation, the mineral residue, and the volatile matter, was in most instances also begun within a few hours after the collection of the sample, and whenever for any reason evaporation had to be postponed this determination has been made at another date on a duplicate sample of the water, and in the few instances in which we have had reason to suspect the solution of the glass of the container by the water of the sample a note has been made to this effect. On account of the great humidity of the atmosphere of the laboratory during the month of August—a month of excessive rainfall in the District of Columbia—and the extremely deliquescent character of certain of the total residues of the shallow wells, we were compelled to postpone the determination of total solids of certain of these waters until September or October, when determinations were made on duplicate samples of the waters. Finally, it should be noted in passing that whenever possible our standards and solutions were checked by comparative determinations on solutions of chemically pure salts.

NUMBER OF SAMPLES OF WATER ANALYZED.

Since July 16, 1906, on which date the bacteriological and chemical examinations of the water supply of the District were begun, sanitary analyses of 283 samples of water have been made in the chemical division of the Hygienic Laboratory. These have included:

(1) Fourteen complete sets of analyses of waters of the reservoirs, the samples of which were taken at weekly or semiweekly intervals,

from July 30 to September 27, 1906, inclusive, from the Dalecarlia inlet and outlet, the outlet of the Georgetown reservoir, the outlet of the Washington City reservoir, and the storage basin near the outlet.

(2) Forty-nine specimens of tap water collected at various points over the city at dates indicated in Table 7, between July 16 and September 28, 1906.

(3) Twenty-three waters of deep wells.

(4) Sixty-three waters of shallow wells.

(5) Eleven specimens of water from small miscellaneous water supplies.

(6) Twenty table waters.

(7) Twenty-seven specimens of ice.

(8) Twenty waters of wells connected with ice plants.

In addition to this, duplicate determinations of chlorine, nitrites, and nitrates, and in many instances of total solids, have been made on all of the well waters, 86 in number, with the view of detecting any variation in the nature and amount of the impurities, and, as may be seen from Tables 8, 9, 10, 11, and 12 in the case of certain of the well waters, some of these determinations have been made several times and at different dates during the period covered by this investigation.

OTHER CHEMICAL INVESTIGATIONS OF THE WATER SUPPLY OF THE DISTRICT OF COLUMBIA.

Through the courtesy and cooperation of Doctor Woodward, Doctor Lynch's analyses of the well waters of the District have been placed at our disposal, together with his (Lynch's) analyses of a number of samples of ice manufactured in the District. We have also availed ourselves of the large amount of analytical data on the Potomac water supply contained in Senate Document No. 259, Fifty-sixth Congress, first session, and in Senate Report No. 2380, Fifty-sixth Congress, second session, by Charles Moore, etc.

In 1891 the well waters of the District, of which at that time there were 270, were very carefully analyzed by Clifford Richardson. The results of his investigations on this subject were published in the Journal of Analytical and Applied Chemistry (vol. 5, pp. 1–36), and ordinarily would furnish valuable data for comparison, particularly as throwing light on the variation in the composition of the well waters during this comparatively long period. Of the 270 wells existing at the time that Richardson made his analyses, however, by far the greater number have been closed and most of those now in use throughout the District have been opened since his analyses were made, so that comparatively few comparisons are possible. In a general way, however, his analyses show essentially the same condition of the water of the shallow wells that prevails to-day. He

found the greater number of these waters to contain large amounts of chlorine and nitrates; if anything, somewhat larger amounts than have been found by Longley, Lynch, and myself in the waters of such shallow wells as are in use to-day. He arrived at the conclusion that only 27 per cent of these waters were "passable," the remainder being polluted.

We have included also in our tables the results of the analyses made by these several chemists, to whom due acknowledgment is hereby made, and any conclusions which have been arrived at respecting the pollution of any of these water supplies have been reached from a study of all of the analytical data available at the present time.

The results of our analyses, together with those obtained by other investigators, are given in the following tables:

Number of table.	Subject of table.
1 and 2	The waters of the reservoirs and storage basin.
3, 4, and 5	Analyses of the water of the Potomac River.
6	Analyses of the waters of several American rivers.
7	Taps and hydrants.
8	Analyses of the waters of deep wells in the District of Columbia.
9, 10, 11, and 12	Analyses of the waters of shallow wells in the District of Columbia.[a]
13	Condition of shallow wells as shown by chemical analysis.
14	Condition of shallow wells as shown by the bacteriological examination.
15	List of shallow wells regarded as unfit for drinking purposes.
16	Summary of results of analyses of the water of the reservoirs and storage basin. (July to October, 1906.)
17	Summary of Longley's analyses of the water of the reservoirs and storage basin. (February to June, 1906.)
18, 19, 20, 21, 22, and 23	Chemical purification of Potomac water due to subsidence and filtration.
24	The composition of tap water as compared with the waters of the Dalecarlia reservoir, inlet, and the storage basin.
25	Analyses of tap water, compared for different short periods, during the summer of 1906.
26	Analyses of tap water supplied the city of Washington, during the summer of 1904 and 1906.
27	Results of analyses of miscellaneous water supplies:
	(1) The Government Hospital for the Insane (St. Elizabeth's).
	(2) The Soldier's Home.
	(3) Chevy Chase.
	Chemical analyses and results of bacteriological examination of table waters.[b]
	Chemical analyses and results of bacteriological examination of ice sold in the District of Columbia.[b]
	Chemical analyses of ice manufactured in the District of Columbia, by Doctor Lynch.[b]
	Chemical analyses and results of bacteriological examination of wells in use in ice factories in the District of Columbia.[b]

[a] In Tables 8, 9, 10, 11, and 12, the results given immediately following the laboratory number of the given well are our own. Those marked "L" are the results of Longley's analyses, those marked "Ly" were obtained by Lynch, and those marked "R" were obtained by Clifford Richardson.

[b] Given in other sections of the report.

INTERPRETATION OF THE RESULTS OF THE SANITARY ANALYSES OF THE WATER SUPPLIES OF THE DISTRICT OF COLUMBIA.

Since the celebrated Broad street well investigation (London), in 1854, which, according to Kinnicutt[a] was the first to attract general attention to the fact that there might be a connection between the use of polluted water and disease, various attempts have been made, especially by English chemists, to devise chemical methods and standards whereby the sewage pollution of a given water could be accurately measured. The earlier investigations on this subject were made by Frankland[b] (member of the Rivers Pollution Commission, London), Wanklyn, Chapman, and Smith,[c] and by Tidy.[d]

It is interesting to note that these investigators were by no means agreed as to the methods and standards best suited for measuring the pollution of natural waters. As a matter of fact their labors in this field immediately gave rise to one of the most prolonged controversies on this subject, a controversy which, in one form or another, has been carried on more or less vigorously from that time down to the present. The result has been that no sooner has one standard been agreed upon by one chemist and his immediate followers than its value has been called in question by others, and other methods and standards substituted in its place. That this matter is still the subject of much discussion and much difference of opinion may be seen from the titles of three very interesting communications on this subject, of recent date, by three American chemists, all of whom have had a wide experience in this particular field of chemical investigation, and a very good idea of the present condition of sanitary water analysis may be gained from a study of these three communications, viz: "The sanitary value of a water analysis," by Leonard P. Kinnicutt (Science, N. S., Vol. XXIII, 1906, No. 576, pp. 56–66); "Interpretation of a water examination," by W. P. Mason (Science, N. S., Vol. XXI, No. 539, pp. 648–653), and "The futility of a sanitary water analysis as a test of potability," by Marshall O. Leighton (in Biological Studies by the Pupils of William Thompson Sedgwick, Boston, 1906, pp. 36–53).

Without entering more fully into the merits of this very vexed question, concerning which doubtless much remains to be said on both sides, it may be stated briefly that it is the general concensus of opinion of those most competent to deal with the subject of water pollution, that no one is any longer justified in passing judgment on

[a] Science, N. S., XXIII, p. 57.

[b] Jour. Lond. Chem. Soc., XXI (1868, pp. 77–108, and ibid., Vol. XXIX (1876), pp. 825–851, also Reports of Rivers Pollution Commission (London), (1866–1874).

[c] Ibid., Vol. XX (1867), pp. 445–454, and Vol. XXI (1868), pp. 152–172, and also "Water analysis," by Wanklyn and Chapman, London, 1868.

[d] Ibid., Vol. XXXI (1879), pp. 46–106.

the potability of a given water from the chemical analysis alone, but that in order to form a correct opinion on this point, three things at least have to be taken into consideration: First, the source of the water and the sanitary conditions of the watershed; second, the number and character of the microorganisms present in the water; and third, the chemical composition of the water, or rather the nature and amount of the impurities contained therein, paying particular attention of course to those substances whose presence in quantities over and above certain more or less arbitrarily fixed amounts have generally been agreed upon by investigators in this field as indicating pollution, viz, chlorine, nitrogen in the form of free and albuminoid ammonia, nitrites, nitrates, oxygen required, etc., and also to the gross physical characteristics of the water, such as color, turbidity, odor, sediment, etc.[a]

According to Whipple[b], a pure and wholesome water—

> must be free from all poisonous substances, as the salts of lead; must be free from bacteria and other organisms liable to cause disease, such as the bacilli of typhoid fever or dysentery; it must also be free from bacteria of fecal origin, such as B. Coli. In other words, the water must be free from poisonous substances, from infection, and even from contamination[c]. Besides this, it must be practically clear, colorless, odorless, and reasonably free from objectionable chemical salts in solution and from microscopic organisms in suspension. Moreover, it must be well ærated. Color, turbidity, odor, dissolved salts, etc., may be permissible to a small degree without throwing the water outside of the definition of pure and wholesome waters. In these minor matters, local standards govern up to a certain point, and it is in regard to them that differences in the judgment and experience of analysts lead to different classifications.

According to the same author:

> If the water under consideration has been used for a considerable time, the typhoid fever death rate of the community will fairly well represent the sanitary quality of the water supply. It will not tell the whole story, but in many cases it will not lead far astray.

A consideration of the results of our own analyses and those of other analysts, of the several water supplies of the District of Columbia, in the light of these several criteria for judging the purity and wholesomeness of a water, leads to the following conclusions:

It will be seen from the summaries of analyses given in Tables 1 and 2 that the water of Dalecarlia reservoir at the inlet shows more

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[a] See the following authorities: Mason, Water Supply (1898), p. 360; see also Mason, "Examination of Water" (1901), Introduction, pp. 1–6; also Clifford Richardson, "Characteristics of Well and Spring Waters in a Thickly Populated Area," Jour. Anal. and Appl. Chem., Vol. V (1891), p. 22, section 5. Palmer, "Chemical Survey of the Waters of Illinois" (1903), pp. 37–41. Richards and Woodman, "Air, Water, and Food" (1901), pp. 67–81. Leffman, "Examination of Waters," 5th ed. 1903, p. 108.

[b] "The value of Pure Water," by George C. Whipple, Biological Studies by the Pupils of William Thompson Sedgwick, Boston, 1906, p. 54–77.

[c] In a footnote this author says by this term (meaning contamination) is meant pollution with fecal matter. Contamination must be considered as potential infection.

free and albuminoid ammonia and more nitrites and requires considerably more oxygen to oxidize the organic matter present in the water than we would expect of a safe and potable water. The quantity of chlorine is small, and in the present state of our knowledge regarding the normal chlorine for the Potomac watershed, throws but little, if any, light on the degree of pollution of Potomac water. According to information kindly furnished us by Mr. Leighton, chief of the hydrographic division of the United States Geological Survey, many attempts have been made to determine the normal chlorine for the District of Columbia and the Potomac drainage area with but little success. In a letter dated November 27, 1906, he says:

I feel fairly sure that the normal chlorine for the District is not far from three parts per million; yet our results vary from 1.6 to 7.8 parts.

In view of these uncertainties regarding the normal chlorine, the amount of chlorine found in the Potomac water at the Dalecarlia inlet throws but little light on the subject under consideration—namely, the degree of pollution of the water of the Potomac. The quantity of nitrates is small, and the water is well aerated, containing an average of 7.44 parts per million of dissolved oxygen, corresponding to 89.6 per cent saturation. Except after a heavy rain, the total solids left on evaporation are small. The residue from evaporation has always been found to char considerably on ignition, and the odor evolved on burning is something like that of burning wood, and also somewhat disagreeable. The turbidity, color, odor, and sediment vary greatly with the rainfall. After a long dry spell the water of the river is reasonably clear, and at such seasons it shows only a slight turbidity and yields only a small amount of sediment on standing. After and during periods of heavy rainfall, however, the river is muddy and the turbidity of the water is great, and on standing it yields a considerable amount of sediment, chiefly clay. The odor of the unfiltered river water may be described as earthy or woody, and during the period covered by our observations nothing particularly disagreeable or objectionable in the odor was observed.

For the sake of comparison we have included in Tables 3, 4, and 5 the results of analyses of Potomac water made by various analysts at different times, and also in Table 6 the analyses of the waters of a number of American rivers. It is evident from the results given in Table 4 that the water of the Potomac is liable to considerable variation in the amounts of the several impurities. These variations can be readily understood when it is borne in mind that the Potomac drains a more or less greatly diversified, hilly, and mountainous region, over which the rainfall varies greatly at different seasons of the year, and in fact during the same season. Casual inspection of the river is all that is required in order to form an idea of the extremely variable

and fluctuating character of Potomac water. During a large part of the month of November, 1906, the river was low and the water relatively clear and free from mud; during the months of July and August, on the other hand, the river was quite high and the water muddy and extremely turbid. The purification of the Potomac water supply presents much the same problem that has been encountered in the purification of the waters of our southern rivers, which, at certain seasons of the year, contain large amounts of clay in suspension, thereby causing sudden and extreme variations in turbidity.[a]

PURIFICATION OF THE POTOMAC WATER SUPPLY BY SUBSIDENCE AND FILTRATION.

As the water of the Potomac River passes through the several reservoirs on its way to the sand filters, the flow of the water becomes less rapid and certain chemical and bacteriological changes occur, all tending toward a considerable purification of the water. A further purification of the water is effected by sand filtration. That such is the case may be seen from the general summary of the results of our analyses of the waters of the reservoirs and storage basin given in Table 16, and also from the summary in Table 17, giving the results of the analyses made by Mr. Longley of 20 weekly samples of the waters of the reservoirs and storage basin covering a period from February 13 to June 26, 1906. These two sets of analyses show a reasonable agreement, especially when it is borne in mind that they were made at different seasons of the year and that the water of the Potomac is subject to considerable variation. It will be seen from Table 16 that during the period covered by our examination of the waters of the reservoirs, viz, from July 30 to September 27, 1906, the average turbidity gradually diminished in passing from the inlet of the Dalecarlia reservoir to the filter beds from an average of 221 at Dalecarlia inlet to 46 in the Washington City reservoir. There was also a gradual falling off of about one-third in total solids and mineral matter, and also about the same diminution in the quantities of free and albuminoid ammonia. The oxygen consumed also showed a falling off of about one-fourth, the nitrates and dissolved oxygen remaining practically the same as at the inlet, whereas the nitrites were found to increase gradually from 0.0031 parts per million at the Dalecarlia inlet to 0.0065 parts per million in the Georgetown reservoir, and then to decrease to 0.0056 parts per million in the Washington City reservoir. The chlorine was also found to diminish slightly in passing through the series of reservoirs, so that the general effect of the slow passage of the water through the reservoirs

[a] See statement of G. W. Fuller in "Purification of the Washington Water Supply," by Charles Moore, pp. 41–42.

is to improve it considerably as the result of oxidation and subsidence. In Tables 18 to 23, inclusive, which have been compiled from the data given in Tables 16 and 17, will be found numbers representing the actual physical and chemical improvement of the water due to subsidence and filtration. This improvement is expressed in parts per million and also in per cent.

On passing from the Washington City reservoir through the sand filters the Potomac water is still further purified. That such is the case may be seen from Tables 20 and 21.

It will be observed that the sand filters effect a reduction in the turbidity of the water amounting to 90 per cent. The general parallelism between turbidity and bacterial improvement, as shown by the curves in Fig. I, is also a matter of interest in this connection. It will also be seen from Tables 20 and 21 that there is a slight reduction in the amount of total solids, especially in the amount of mineral matter. The amount of chlorine remains practically the same as in the water of the Washington City reservoir. There is a falling off in the amount of the albuminoid ammonia as the result of filtration amounting to 43.7 per cent and an improvement in the water as shown by the quantity of oxygen consumed amounting to 33.3 per cent. Perhaps the most striking chemical difference, however, between the water of the Washington City reservoir and the effluent is seen in the quantities of nitrites present in the two waters. It will be observed that the effect of filtration has been to accomplish the removal of 94.6 per cent of the nitrites present in the water of the Washington City reservoir, and yet, as may be seen from Table 16, the nitrites show a gradual increase in the slow progress of the water through the reservoirs, so that in reality the water of the Washington City reservoir contains a larger quantity of nitrites than the river water at the Dalecarlia inlet. The effect of filtration is to remove the nitrites almost completely. In itself this change in the amount of nitrites from 0.0056 parts per million in the water of the Washington City reservoir to 0.0003 parts per million in the effluent of the filters is insignificant, and yet, considering the real significance attaching to the presence of even very small amounts of nitrites in natural waters, it is of really great importance as throwing light on the chemical changes accomplished by filtration. The disappearance of the nitrites is accompanied by a slight increase in the amount of nitrates present in the filtered water as compared with the water of the Washington City reservoir, and also by a loss of dissolved oxygen amounting to 16.7 to 21 per cent. These changes go to show that not only do the sand filters effect a mechanical purification of the applied water by straining out any particles that may be held in suspension, but also that they effect a still further purification of the water through processes of oxidation. That such is

FIG. I.—CURVES SHOWING THE PARALLELISM BETWEEN TURBIDITY AND NUMBER OF BACTERIA PER CUBIC CENTIMETER IN THE SEVERAL RESERVOIRS. (See Page 286.)

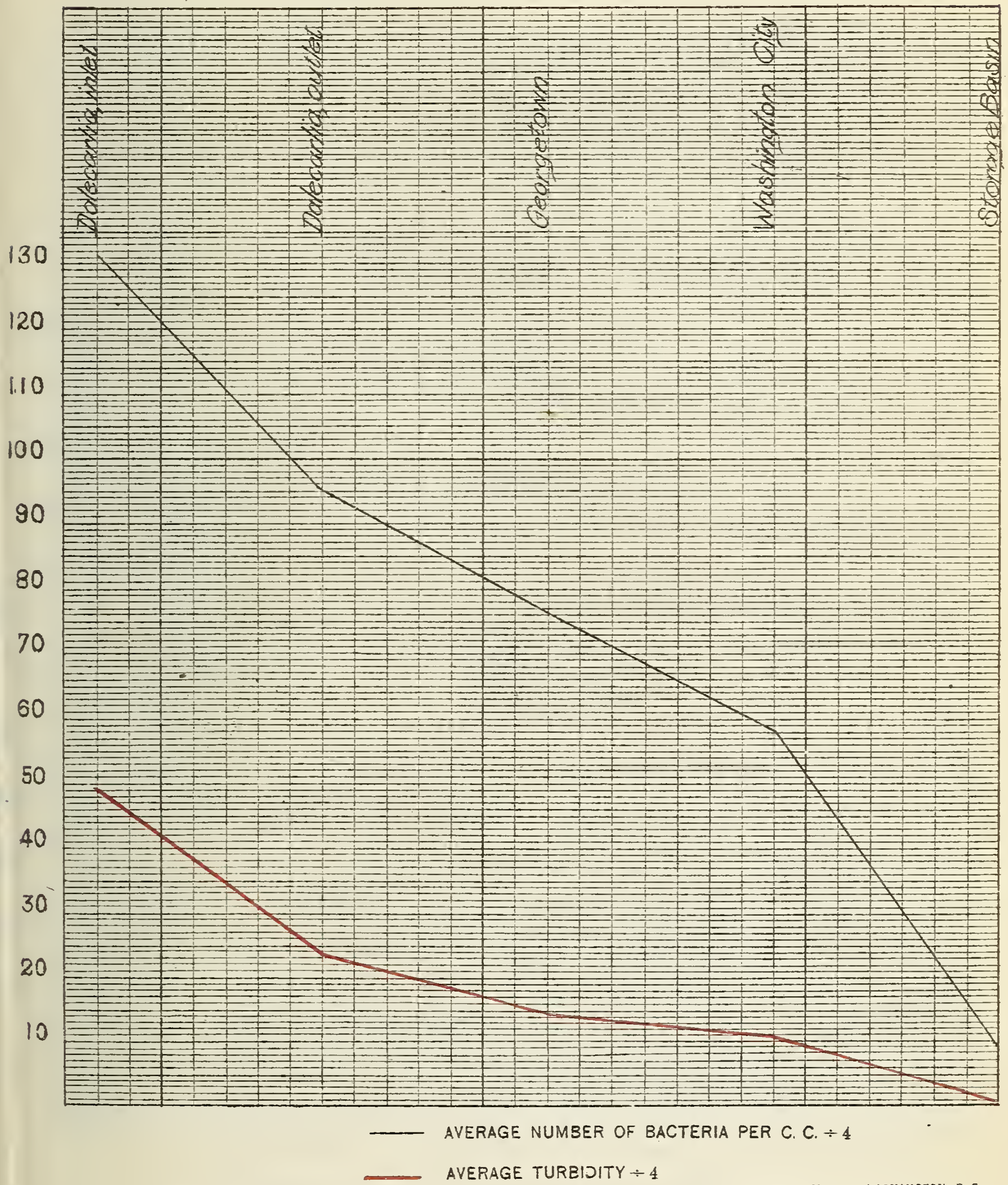

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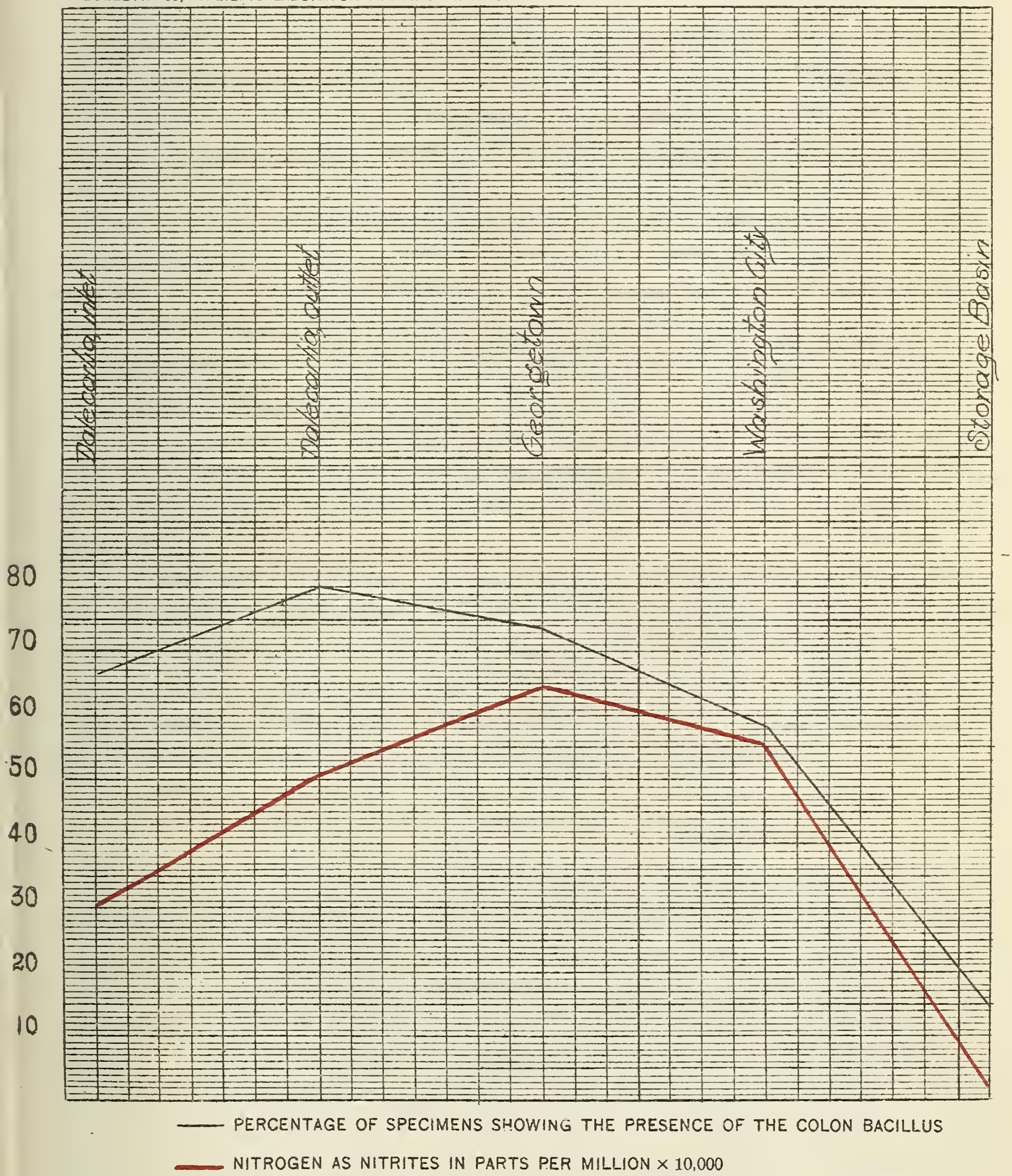
FIG. II.—CURVES SHOWING THE PARALLELISM BETWEEN THE PERCENTAGE OF SPECIMENS SHOWING THE COLON BACILLUS AND THE QUANTITIES OF NITRITES IN THE SEVERAL RESERVOIRS.



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the case is also evident from the fact that while the oxygen required to oxidize the organic matter present in the water of the Washington City reservoir amounts to three parts per million; in the filtered water only two parts are required, indicating a removal through filtration of oxidizable material amounting to 33.3 per cent of that present in the applied water. When it is borne in mind that any considerable quantity of nitrites in water indicates that changes due to living organisms are taking place in the water and that, as has been observed, the amount of nitrites in the waters of the reservoirs rapidly increases in amount on standing, whereas it increases only with extreme slowness in the effluent, the decrease in the amount of nitrites brought about by filtration is, in this particular instance at least, a reasonably good index of the bacterial purification of the water. As compared with the water of the Washington City reservoir, the filtered water shows a diminution in the amount of nitrites present in the water amounting to 96.4 per cent. It will be seen from the curves in Fig. II that a close parallelism exists between the several amounts of nitrites in the several reservoirs and the percentage of specimens showing the colon bacillus. In this connection it has been pointed out by Mills [a] that the vigorous nitrification taking place in the sand filters results not only in the burning up of nearly all of the organic matter, but also in the destruction of pathogenic organisms.

It is evident, therefore, that as nearly as can be determined from the results of the chemical analyses, slow sand filtration has effected a considerable improvement in the quality of the Potomac water. Unfortunately, however, chemical methods are not sufficiently delicate to throw much light on the actual efficiency of sand filtration so far as the removal of dangerous pollution is concerned.

THE WATER OF TAPS AND HYDRANTS.

As may be seen from an examination of Tables 2, 7, and 24, the differences in composition between the filtered water of the storage basin and the water delivered at various taps and hydrants are so slight as to be practically meaningless, in the light of our present chemical standards for determining the potability or pollution of a water. If they amount to anything at all, the slight differences found to exist in the composition of the filtered water of the storage basin and that flowing from taps and hydrants in the city are in favor of tap and hydrant water. The total solids and mineral matter are slightly less in tap water than in the filtered water of the storage basin, and the same is true of free and albuminoid ammonia, nitrites, and oxygen consumed. The amount of dissolved oxygen

[a] See Mason, Water Supply, New York, 1898, p. 127.

has also been found to be about 10 per cent higher in tap water than in the freshly filtered water, indicating, as might be expected, that some aeration takes place after the filtered water leaves the basin. On the other hand, the nitrites are practically the same in both, whereas the chlorine and volatile matter were found to be slightly greater in tap water than in the water of the storage basin. As already stated, however, none of the differences are sufficiently great to be of any real significance. On the other hand, as may be seen from Table 25, during a period of about eleven weeks, from July 16 to September 28, the tap water showed a slight improvement in quality. An inspection of our results will show a greater or less diminution in the quantities of free and albuminoid ammonia and nitrites, and also a decrease in the amount of oxygen consumed, and while on account of delay in securing the necessary apparatus it was not possible to make daily readings of the turbidity of the tap water when this investigation was first undertaken, it is a matter of general observation that the water delivered from the taps and hydrants throughout the city during the months of August, September, October, November, and part of December was considerably better, so far as its general appearance is concerned, than it was when the present investigation was begun. When this investigation was begun, the specimens of tap water brought into the laboratory from various localities throughout the city showed a distinct yellowish color and a slight though quite perceptible turbidity, and one specimen at least was markedly unattractive in both regards. On the other hand, the specimens collected at a later period during the investigation showed practically no color and no turbidity; especially was this the case with the specimens of tap water examined on September 28, and this high efficiency of the sand filters, so far as the removal of color and turbidity is concerned, was steadily maintained during the months of September, October, November, and the greater part of December.

Toward the end of December, 1906, however, the water supplied the city of Washington again became more turbid. Daily turbidity readings during the month of January, 1907, on samples of water collected from a number of taps and hydrants over the city show the tap water to have had an average turbidity of 12 as compared with an average turbidity of 2 to 3 during the months of July, August, and September, 1906, so that for some reason there was, so far as turbidity is concerned, a distinct deterioration in the quality of the water delivered to the city during the month of January. This increase in turbidity was nearly coincident with the onset of the very cold weather on or about December 24, 1906.

By way of further comparison there is submitted in Table 26 a summary of the analyses of tap water for the summer period of

1904,[a] before the filter plant was put into operation, and for the same period of 1906, after the filter plant had been in operation for a period of six to nine months. Considerable and significant differences are noticeable, especially in showing the diminution in the amount of total solids and in free and albuminoid ammonia and in nitrites, which has been effected by sand filtration.

DEEP WELLS.

At the present time there are 24 deep wells in use as a part of the public water supply of Washington and the District of Columbia. Most, if not all, of these deep wells have been found to contain small amounts of iron, and while less attractive than the waters of many of the shallow wells these waters are characterized by great chemical purity. It will be seen from an examination of Table 8 that as a rule they are low in total solids. In the greater number of them chlorine is present only in very small amounts, and in the few instances in which it is present in larger quantities it is associated with very small amounts of nitrates, indicating that the larger quantity of chlorides in these few instances is probably derived, not from remote sewage pollution, but from saline deposits. These waters are also free from nitrogen in its various combinations. Albuminoid ammonia, nitrites, and nitrates are either absent altogether or, if present, only in very small amounts, and in only two instances, viz, Nos. 108 and 110, has the free ammonia been found to be present in such quantities as to cast some suspicion on the purity of the water. In these two waters the bacterial count was also found to be somewhat higher than in the waters of other deep wells. It has been found, however, that the waters of deep wells may often contain rather large amounts of ammonia, which in such cases is believed to result from the gradual reduction of nitrates.[b] The fact that these waters contain practically no nitrates, in most instances even a smaller amount than the surface water of this region, is in keeping with this view regarding the origin of ammonia in deep wells, so that, taking all things into consideration, we find no reason to regard these waters as in any way polluted; indeed, so far as we have been able to determine the waters of these deep wells leave practically nothing to be desired so far as purity is concerned. The presence of iron in these waters doubtless has a great deal to do with their purity and freedom from pollution. In the main at least, this iron exists in the form of ferrous carbonate. This is derived from ferric oxide contained in the rocks and soil through which the water flows by the

[a] The Potomac River Basin, Water-Supply Paper No. 192, by Horatio M. Parker.

[b] See "Air, Water, and Food," by Richards and Woodman (1901), p. 76, and also Mendelejeff, Chemistry, p. 223.

reducing action of the organic impurities of the water and soil. In this manner the organic matter originally contained in the water is oxidized and in the presence of the dissolved oxygen naturally present in surface waters these processes would occur over and over again until all the organic matter originally present in the water had been oxidized and all of the dissolved oxygen consumed. Hence it is that by acting as an oxygen carrier the iron accomplishes both the oxidation of the organic impurities originally present in the water and the removal of the dissolved oxygen. In this way we can satisfactorily account for the freedom of the water of deep wells from organic pollution.[a]

SHALLOW WELLS.

At the present time the waters of 63 shallow wells are in use for drinking purposes in the city of Washington and the District of Columbia. They are widely scattered over the city and are probably used for drinking purposes by a considerable number of persons, especially among the poorer classes. Twenty-nine of the shallow wells now in use are located in the northwest section of the city, 13 in the northeast section, 20 in the southeast, and 1 in the southwest. As a general thing the waters of the shallow wells are very attractive so far as their appearance is concerned. They are clear and sparkling and even during the hottest part of the summer their temperature was rarely found to exceed 20° C. So that among a great number of people the use of these waters for drinking purposes does away with the necessity for the use of ice during the summer months. Unfortunately, however, nearly all of these waters show unmistakable evidences of pollution, either immediate or remote, so that their use for drinking purposes must always remain a menace to the health of the community. It will be seen from an examination of the results of the analyses given in Tables 9, 10, 11, and 12 that as a rule the waters of the shallow wells contain considerable amounts of total solids, consisting for the most part at least of perfectly soluble salts. These waters are also characterized in most instances at least by the presence of large amounts of chlorine and nitrates, indicative of remote sewage pollution, and in a fewer number of instances by the presence of relatively large amounts of nitrites and free and albuminoid ammonia. In many of the wells showing large amounts of chlorine and nitrates, the waters show only small amounts of nitrites and free and albuminoid ammonia, indicating that the pollution is remote, and that sufficient time has elapsed between the pollution of the water by sewage and its entrance into the well to permit of the complete oxidation of the polluting substances. While as with the other impurities the greatest difference of opinion exists as to the significance of nitrates in

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[a] See also "The Filtration of Public Water Supplies," by Hazen (1900), p. 187.

drinking water, it is generally admitted that an excess of these substances must be looked on as an unfavorable indication with respect to the purity of the water and its potability. According to Frankland,[a] "While the oxidation of animal matters in solution in water yields an abundance of nitrites and nitrates, vegetable matters furnish under like circumstances none or mere traces of these compounds," and according to Ekin,[b] the presence of nitrates in large amounts points to sewage contamination. Stoddart[c] also states that "Natural waters can, at most, contain but from 1.43 to 2.86 parts per million of nitrogen as nitrates from sources other than animal matter, and that practically the whole of the nitrogen of sewage may be oxidized to nitric acid without diminishing the risk involved in drinking it." He regards the proposal to regard a water as safe as soon as the nitrogen has been oxidized to nitrates, irrespective of the quantity present, as entirely irrational. Mallet[d] is also inclined to lay great stress on the determination of nitrates in drinking water, with the view of obtaining a correct notion of the extent of sewage pollution.

In Table 13 are given the shallow wells which, according to the chemical analyses, show: (1) Immediate sewage pollution; (2) remote pollution; (3) no pollution at all. In Table 14 are given the shallow wells which, according to the results of the bacteriological examination, have been classified as being: (1) Polluted by sewage or surface contamination; (2) fair; (3) good. In Table 15 is to be found a list of the shallow wells which, on account of insanitary environment and the unfavorable results of the bacteriological and chemical examinations, are regarded by this board as unfit for drinking purposes. It will be seen from a comparison of Tables 13 and 14 that of the 31 shallow wells regarded by us as unfit for drinking purposes 18 were condemned independently by both the bacteriological and chemical examinations, and of the remaining 13, 12 showed bacteriological evidence of immediate sewage pollution and 1 was good; 11 gave chemical evidences of remote sewage pollution, 1 of immediate sewage contamination, and 1 showed no pollution at all.

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[a] Rivers Pollution Commission, Report VI, 1874, p. 13.

[b] Potable Water, Ekin (1890), p. 11.

[c] Analyst, XVIII, p. 293. See also Mason, Examination of Water (1901), pp. 41–42.

[d] Report of National Board of Health, 1882. See also Mason, "Interpretation of a Water Examination," Science, N. S., Vol. XXI, No. 539, pp. 650–651.

In the following table are given the total number of shallow wells in use in the several sections of the city, together with the total number in each section regarded as unfit for drinking purposes:

Section of the city.	Total number of shallow wells in use.	Total number condemned as unfit for use.
Northeast	13	6
Northwest	29	13
Southeast	26	11
Southwest	1	1
Total	63	31

It will be observed that, leaving out of consideration the southwest section of the city, in which but one shallow well is in use, and that a highly polluted one, the number of wells regarded as unfit for use in various portions of the city bears to the whole number of wells now in use in the several sections of the city about the same ratio, viz, about one-half. In other words, it is evident from our studies that the polluted wells are not confined to any particular section of the city, but are about equally distributed over the entire community.

Viewed in all of its aspects, the situation with regard to the shallow wells in the District does not seem to be greatly improved, except as to the fewer number of wells in actual use over what it was fifteen years ago. In 1889, 310 wells were in use in the District, 75 per cent of which, according to the report of the engineer of the District for 1889 and 1890, were polluted. According to Richardson, 270 were in use in 1891, and from his analyses he was led to regard only 27 per cent of them as "passable."[a] According to our findings, of the 63 in use to-day 50 per cent are polluted, and of the remaining 50 per cent nearly all show chemical evidences of remote pollution, so that the shallow wells in use throughout the District to-day show but slight improvement in the quality of the water supplied over those in use in 1889. The slight improvements observed can be readily accounted for by the decrease in the number of privies now in use in the city and by the extension and improvement in the sewerage system.

While none of the cases of typhoid fever occurring during the period covered by this investigation were traceable directly to the use of the water of any of the shallow wells, the shallow wells of the District of Columbia must be looked upon as latent sources of danger to the health of the community, and serve to greatly increase the labor incident to the proper sanitary control of the water supply of the District. So far as their effect on the problems of sanitation is concerned each well must be looked upon as an independent water sup-

[a] Jour. of Anal. and Appl. Chem., Vol. V., pp. 1–36.

ply in itself, which must be properly safeguarded by constant inspection and numerous bacteriological and chemical examinations. It is evident, therefore, that while they supply a considerable number of persons with cool, palatable drinking water they are constantly subject to sewage pollution, and serve to greatly increase the complexity of a situation in public sanitation already exceedingly complex and difficult to control.

TABLE WATERS.

As already stated, our investigation has included the bacteriological and chemical examination of a number of table waters used for drinking purposes throughout the District of Columbia. Chemical analyses of 20 of these waters have been made, the results of which are given in a table, page 163, of this report.[a] It will be seen from an examination of this table that the greater number of these waters showed no chemical or bacteriological evidences of pollution, and probably the greater number of them are pure and wholesome waters. Those showing no chemical evidences of pollution are as follows:

Laboratory No.

238. Pure table water.
357. Gitche Crystal Spring water.
384. Arlington filtered water.
420. Takoma Spring water.
421. Magnolia Spa water.
429. Powhatan Spring water.
447. Castalia Spring water.
457. Great Bear Spring water.
458. F. H. Finley & Son's distilled water.
461. Sparkling Rock Spring lithia.
462. Arlington Springs mineral water.
463. Sprudel Wiesbadner wasser.
471. Poland water.

Of these waters showing no chemical evidences of pollution, Nos. 458, 461, and 471 contained a large number of bacteria per cubic centimeter, which in the case of 458 and 461 is probably to be attributed to carelessness in the handling and bottling of these waters, inasmuch as No. 458 is a distilled water and No. 461 is a manufactured lithia water made by a local firm, probably from tap water by the addition of the necessary saline ingredients.

[a] Four of these waters, viz, Gitche Crystal Spring water, Powhatan Spring water, Great Bear Spring water, and Poland water were analyzed in 1905 by Haywood and Smith. See Bulletin No. 91, Bureau of Chemistry, U. S. Department of Agriculture.

From an examination of the table p. 163 it will be seen that the following waters show some chemical evidences of pollution:

Laboratory No.

371. Red Oak Spring water.
394. Magnesia Crystal table water.
409. Norwood artesian water (unfiltered).
437. Hume Spring water.
438. Crystal Rock table water.
470. M. L. Harper's distilled water.
472. Renal Spring water.

Of these waters six, viz, Nos. 394, 409, 437, 438, 470, and 472, contain considerably larger quantities of nitrites than we would expect a pure, wholesome water to contain, and No. 371 shows too large an amount of albuminoid ammonia. Of the table waters showing chemical evidences of pollution, the following were found on bacteriological examination to contain but few bacteria per cubic centimeter, viz, Nos. 371, 437, and 438, so that it is difficult to account for the large amounts of nitrites present. On the other hand the following waters were found to contain large numbers of organisms per cubic centimeter, thereby confirming the results of the chemical analyses, viz, Nos. 394, 409, 470, and 472.

All things considered, however, it is not likely that the table waters of the District of Columbia are responsible for any of the typhoid fever occurring in this locality.

ICE.

At intervals during the months of August, September, and October chemical and bacteriological examinations were made of the different kinds of ice manufactured and sold in the District of Columbia. The results of these examinations are given in a table, page 106 of this report, and on page 110 are also given the results of Doctor Lynch's analyses of a number of samples of ice sold in the District. It will be seen from an examination of the table p. 106 that but few of the specimens of ice examined showed any chemical evidence of pollution, and according to statements appended to Doctor Lynch's reports none of the samples of ice examined by him showed the presence of any injurious contamination. As a rule the specimens of ice examined in the Hygienic Laboratory were found to contain but small amounts of total solids, and in some instances at least less chlorine than the water from which the manufactured ice was made. This probably results from the purification due to freezing. A number of the specimens of manufactured ice were found to contain relatively large amounts of free ammonia. This frequently happens, however, inasmuch as it has been found to be exceedingly difficult to prevent a slight leakage from the ammonia pipes into the atmosphere of the

factory, so that it is no uncommon thing to find specimens of manufactured ice containing free ammonia in such quantities as to impart a distinctly alkaline taste. Such being the case the presence of large amounts of free ammonia in manufactured ice is no evidence of pollution. On the other hand, specimen No. 12 is a manufactured ice which is evidently made directly from the water of one of the shallow wells in this locality. This particular sample of ice is, according to the chemical results, polluted and unfit for anything except general cooling purposes where it is not brought into immediate contact with drinking water or food. It should also be observed that this particular sample, like the water of many of the shallow wells showing chemical evidences of pollution, contained very few bacteria per cc. As has been found, however, with many waters of the shallow wells the chemical analysis points unmistakably to pollution, and the same considerations which have led us to recommend the abandonment of all of the shallow wells throughout the District would also lead us to condemn the practice on the part of ice manufacturers of making ice directly from the water of such wells. Besides specimen 12, specimens 9, 16, 28, 30, 32, and 33 contained larger quantities of nitrites than might be expected in pure ice, and specimens 6, 8, 13, and 29 contained quantities of albuminoid ammonia either closely approximating or slightly exceeding the limit assigned by Wanklyn and Chapman, viz, 0.08 parts per million for a safe water. Three specimens of the ice showing large quantities of albuminoid ammonia, viz, Nos. 8, 13, and 29, were also found by the bacteriological examination to be either polluted or suspicious, while No. 6 according to the bacteriological findings was of good quality, and similarly no evidences of bacterial pollution were found among those specimens showing large amounts of nitrites. On the other hand a number of specimens showing no chemical evidences of pollution were found as the result of the bacteriological examination to be suspicious or polluted. Such was the case with specimens 1, 2, 5, 7, 10, 14, 26, and 34. This lack of agreement between the chemical and bacteriological findings in the case of these several specimens of ice is doubtless to be accounted for in the following manner: It is probable that the specimens of ice showing bacterial contamination, but giving no chemical evidences of pollution, really received their bacterial contamination through uncleanliness and careless handling, either immediately before, during, or after freezing, in which event while the organisms or at least a certain number of them might remain alive, their growth and development would be so interfered with at this low temperature that the products of their life and growth would not accumulate in the ice in sufficient amounts to give chemical evidence of pollution. In this way a pure water might become seriously contaminated bacterially, either immediately before or during or immediately after

freezing, and the ice, even if kept for a considerable period after manufacture, fail to show any chemical evidences of such pollution. On the other hand, it is conceivable that a polluted water might after freezing show chemical evidences of pollution and yet be practically sterile, for the reason that the substances indicating pollution are not destroyed by freezing and may persist in the water (or ice) long after the bacteria causing these changes have perished. Hence it is that among a considerable number of samples of ice we might expect to encounter a greater number of discrepancies between the chemical and the bacteriological findings than among an equal number of specimens of water, and such has been our experience.

WELLS IN USE BY THE ICE FACTORIES OF THE DISTRICT OF COLUMBIA.

The present investigation has also included the bacteriological and chemical examination of the waters of 21 wells which are used for one purpose or another in the various ice factories now in operation in the District of Columbia. According to the statements of the manufacturers the waters of these wells, in most instances at least, are employed only for purposes of condensation and not in the manufacture of the ice itself. The use to which the water of any particular well of this series is put is indicated in the column headed "Remarks" of the table p. 105 of this report. The results of our bacteriological and chemical examinations of the waters of these wells are also given in this table, from which it may be seen that so far as chemical evidences of pollution are concerned, the waters of this group of wells may be classified as follows:

PURE.

No. of sample.

251. Hygienic Ice Company, Fifteenth and E streets NE.
252. Hygienic Ice Company, Fifteenth and E streets NE.
255. Hygienic Ice Company, Fifteenth and E streets NE.
256. Hygienic Ice Company, Fifteenth and E streets NE.
257. Hygienic Ice Company, Fifteenth and E streets NE.
272. Purity Ice Company, Fifth street market NW.
273. Purity Ice Company, Fifth street market NW.
295. Corby Company, Langdon, NE.

REMOTE POLLUTION.

238. Home Ice Company, Twelfth and V streets NW.
240. Home Ice Company, Twelfth and V streets NW.
241. Home Ice Company, Twelfth and V streets NW.
253. Hygienic Ice Company, Fifteenth and E streets NE.
254. Hygienic Ice Company, Fifteenth and E streets NE.
266. Auth Provision Company, Seventh and Virginia avenue SW.

SUSPICIOUS.

265. Auth Provision Company, Seventh and Virginia avenue SW.
267. Center Market, Seventh street NW.
268. Chas. Javins & Sons, 930 C street NW.

POLLUTED.

239. Home Ice Company, Twelfth and V street NW.
258. Hygienic Ice Company, Fifteenth and E streets NE.
271. Purity Ice Company, Fifth street market NW.

According to the bacteriological findings, these waters may be classified as follows:

GOOD.

No. of sample.

238. Home Ice Company, Twelfth and V streets NW.
240. Home Ice Company, Twelfth and V streets NW.
241. Home Ice Company, Twelfth and V streets NW.
251. Hygienic Ice Company, Fifteenth and E streets NE.
252. Hygienic Ice Company, Fifteenth and E streets NE.
254. Hygienic Ice Company, Fifteenth and E streets NE.
255. Hygienic Ice Company, Fifteenth and E streets NE.
256. Hygienic Ice Company, Fifteenth and E streets NE.
257. Hygienic Ice Company, Fifteenth and E streets NE.
265. Auth Provision Company, Seventh and Virginia avenue SW.
266. Auth Provision Company, Seventh and Virginia avenue SW.
268. Chas. Javins & Sons, 930 C street NW.
272. Purity Ice Company, Fifth street market NW.
273. Purity Ice Company, Fifth street market NW.
295. Corby Company, Langdon, NE.

SUSPICIOUS.

227. Hygienic Ice Company, Fifteenth and E streets NE.
253. Hygienic Ice Company, Fifteenth and E streets NE.
258. Hygienic Ice Company, Fifteenth and E streets NE.
267. Center Market, Seventh street NW.
271. Purity Ice Company, Fifth street market NW.

POLLUTED.

239. Home Ice Company, Twelfth and V streets NW.

MISCELLANEOUS WATER SUPPLIES IN THE VICINITY OF WASHINGTON.

THE GOVERNMENT HOSPITAL FOR THE INSANE.

The Government Hospital for the Insane, St. Elizabeth's, is supplied with water from eight artesian wells, 375 feet in depth. The wells, pump house, and storage cistern are located in the river bottom, near the Eastern Branch of the Potomac River. According to the engineer in charge of the pump house, no solid rock was encountered in drilling these wells. The wells themselves are incased in iron pipes 6 to 8 inches in diameter and are thoroughly protected against surface contamination. The water is forced out of the wells by means of compressed air and, after leaving the outlet of the iron pipes,

flows by gravity to the storage cistern. This cistern is made of brick and cement and has a capacity of 80,000 gallons. It communicates with the outside air by means of a terra-cotta pipe of large diameter, 3 feet in height above the roof of the cistern. This pipe is freely open to the air and might occasionally be the means of conveying pollution to the water in the cistern, although we were assured by the engineer in charge that a careful watch was kept over it.

These wells have been in use for over two years, during which time they have supplied the institution with an abundance of pure water. The results of the chemical analyses of this water supply are given in Table 27. It will be observed that the water of the wells is low in total solids, and also in free and albuminoid ammonia, nitrites and nitrates, and oxygen consumed. Like most of the deep-well waters of this locality, it contains small amounts of iron, and while the amount of chlorine is somewhat larger than we have found in many of the deep wells throughout the District, it is really of no significance. The results of our analyses indicate that the present water supply of St. Elizabeth's is pure and wholesome, and this conclusion is borne out by the bacteriological findings and by the freedom of the institution from typhoid fever and other water-borne diseases contracted in the institution since this water supply has been in use.

The following report on typhoid fever in relation to sanitary improvements at this institution was submitted by Assistant Surgeon H. D. Long, Public Health and Marine-Hospital Service:

Year ending—	Sanitary improvements, remarks, etc.	Cases.	
		Attendants.	Patients.
June 30, 1900	Sewer plant completed		2 deaths; number of cases not stated.
June 30, 1901	Six artesian wells drilled		1 death; number of cases not stated.
June 30, 1902	Report states that the six wells are insufficient. River water still used. Milk supply practically all from hospital dairy. Report states eight cases under treatment at time of writing report. No employee of dairy has had typhoid before employment in hospital.	30 Widal tests made; positive in 14 cases; 1 death.	
June 30, 1903	Report states: In April, 1903, number of cases in hospital exceeded entire number of cases in the District of Columbia. Hydrant water found constantly contaminated with sewage. Traced to the fact that as milk supply was insufficient forty gallons of condensed milk were used per diem. This was diluted with hydrant water. When this error (the dilution of condensed milk with hydrant water) was corrected, only two cases developed subsequently. Eight wells in use, four redrilled; average depth, 376 feet.	29 positive Widal tests; 5 deaths.	
June 30, 1904	Complete pasteurizing apparatus purchased and is being installed. Water tank completely scraped, painted, and cleaned. Whole water system flushed out in June, 1904, since which time the water supply has been taken wholly from artesian wells. Separate drinking and general water supply recommended. Total absence of typhoid infection.		

Year ending—	Sanitary improvements, remarks, etc.	Cases.	
		Attendants.	Patients.
June 30, 1905	Pasteurizing apparatus purchased last year installed and in daily use for whole milk supply since November, 1904. No typhoid cases in hospital except two cases which developed in attendants a short time after their employment. Inoculation from external source.	2 cases.	
June 30, 1906	Contract to bore two more wells; work in progress at present time. Five cases of typhoid among attendants; all traced to same source—the use of infected ice cream purchased at a small store outside of hospital. Cases synchronous; wife and two children of storekeeper had typhoid at time of infection. No typhoid among inmates.	5 cases; 1 death.	

We also note that this institution is somewhat isolated, and thus removed from the influence of flies and other factors which operate in the more complex conditions in the city. Further, the new buildings were occupied September to December, 1904, thus relieving the overcrowded condition of the old buildings.

SOLDIERS' HOME.

This institution, while supplied with city water, uses its own supply exclusively for drinking purposes. This supply comes mainly from a well 150 feet in depth, in addition to which there are several other wells and springs scattered over the grounds, from which the inmates occasionally drink while taking exercise about the grounds.

Frequent examinations of these waters have been made by Doctor Carroll at the laboratory of the War Department, with the result that some of the wells at this institution have been closed from time to time. Those now open gave good results on analysis. The water now supplied the institution from the main well has been analyzed both at the Hygienic Laboratory and at the laboratory of the filtration plant. The results of these analyses are given in Table 27. It will be seen that the water is low in total solids, chlorine, free and albuminoid ammonia, and nitrites. It contains a larger quantity of nitrates than we might expect from the depth and location of the well. The bacteriological examination showed no pollution, so that we have every reason to regard this also as a pure and wholesome water. This institution was found also to be free from typhoid fever.

CHEVY CHASE.

This community is supplied with water from 5 artesian wells, varying in depth from 100 to 120 feet. These wells are some distance apart, but all of them are located in the neighborhood of Chevy Chase circle. Each well is incased in a 4-inch iron pipe, through which the water is pumped into a steel standpipe, flowing by gravity from the standpipe to the taps. The delivery mains of two of the wells do not

communicate directly with the standpipe, but connect directly with the distributing mains. The Chevy Chase district school is also supplied with water from a well of its own. The Chevy Chase Park, about 3 miles beyond Chevy Chase circle, is supplied by a pump located at the street-car station and also by a spring at the lower end of the lake. The former has generally been found to be in bad repair, and the spring is so situated that it probably receives some drainage from the road. The waters of this well and spring are used for drinking purposes by the employees of the street car company and by a considerable number of visitors to Chevy Chase Park, especially during the summer months. The results of our analyses of the Chevy Chase waters are given in Table 27. So far as we may judge from the chemical examination, the main water supply of Chevy Chase is pure. Indeed, it seems to be an excellent water, and the same may be said of the spring, although, as already pointed out, its situation is such as would condemn it on sanitary grounds. The well at Chevy Chase school supplies a good water, but the other well located at the Park gave some chemical evidence of pollution.

The results of the bacteriological examinations of these several miscellaneous water supplies are given in the following tables:

Results of bacteriological examinations of the miscellaneous water supplies.

No.	Location.	Date.	Number of bacteria per cubic centimeter.	Ferment in lactose bouillon.			B. coli present.		
				0.1 cc.	1 cc.	10 cc.	0.1 cc.	1 cc.	10 cc.
		1906.							
214	Chevy Chase water supply	Aug. 30	[a] 35	–	+	+	......	......	+
474	Chevy Chase hydrant	Oct. 23	110	......	+	+	......	......	+
215	Chevy Chase district school	Aug. 30	0	–	–	–	–	–	–
475	....do	Oct. 23	0	......	–	–	–	–	–
315	Soldiers' Home, Scott spring	Sept. 21	23	–	–	+	–	–	–
316	Soldiers' Home pump-house tank	....do	37	–	–	–	–	–	–
343	Soldiers' Home	Sept. 28	26	–	–	–	–	–	–
L	....do	....	46	......	......	......	–	–	–
88	St. Elizabeth well	Aug. 6	6	–	–	–	–	–	–
89	St. Elizabeth cistern	....do	6,000	+	+	+	–	–	–
113	....do	Aug. 10	473	–	–	–	–	–	–
112	St. Elizabeth pump No. 2	....do	3	–	–	–	–	–	–
114	St. Elizabeth engine house	....do	149	–	–	–	–	–	–
115	St. Elizabeth administration building	....do	113	–	–	+	......	......	+

[a] In 1 cubic centimeter (?).

TABLE 1.—*Results of analyses of the waters of the reservoirs and storage basin.*

No. of sample.	Name of reservoir.	Date.	General characteristics. Color.	Odor.	Turbidity.	Sediment.
		1906.				
63	Dalecarlia, inlet	July 30	Yellowish brown	Earthy and woody	Great>64	Large>64.
64	Dalecarlia, outlet	July 30	....do	Earthy and woody<63	Considerable<63>65	Considerable<63>65.
65	Georgetown	July 30	Yellowish	Earthy and woody<63=64	Considerable<64>61	Considerable<64.
61	Washington	July 30	Slight yellowish	Slightly earthy	Slight<65	Slight, much<65.
62	Storage basin	July 30	Very slight	None	Very slight	None.
95	Dalecarlia, inlet	Aug. 7	Yellowish brown>96	Woody	Great	
96	Dalecarlia, outlet	Aug. 7	Yellowish brown<95	Woody, earthy>95	Great<95	
97	Georgetown	Aug. 7	Yellowish brown<96	Woody, earthy>96	Considerable<96	
93	Washington	Aug. 7	Yellowish	Very distinctly woody	Considerable<97>94	None.
94	Storage basin	Aug. 7	Very slight	Woody<93	Very slight	Do.
122	Dalecarlia, inlet	Aug. 13	Yellowish brown	Earthy	Great	Heavy yellowish brown.
123	Dalecarlia, outlet	Aug. 13	Yellowish brown<122	Earthy<122	Great<122	Heavy<122.
124	Georgetown	Aug. 13	Yellowish<123	Earthy<123	Considerable<123	Considerable<123.
125	Washington	Aug. 13	Yellowish	Slight earthy	Slight	Slight yellowish.
126	Storage basin	Aug. 13	Very slight	None	Practically none	None.
160	Dalecarlia, inlet	Aug. 21	Slight 9	....do	Considerable	Considerable, brown, heavy.
161	Dalecarlia, outlet	Aug. 21	....do 14	....do	....do	Slight.
162	Georgetown	Aug. 21	....do 10	....do	....do	Do.
165	Washington	Aug. 21	....do 12	....do	....do	Do.
166	Storage basin	Aug. 21	....do 9	....do	Slight	None.
176	Dalecarlia, inlet	Aug. 23	Dark brown	Earthy	Very great 650	Heavy, brown-like clay.
177	Dalecarlia, outlet	Aug. 23	Light brown	Slight earthy	Considerable 200	Fine, brown.
178	Georgetown	Aug. 23	Yellowish	Very slight earthy	....do 105	Do.
173	Washington	Aug. 23	Slight 11	None	....do 90	Slight, brownish.
174	Storage basin	Aug. 23	....do 7	....do	Slight 7	None.
194	Dalecarlia, inlet	Aug. 27	Brown 12	....do	Great 775	Heavy, considerable, like clay.
195	Dalecarlia, outlet	Aug. 27	Light brown 14	....do	Considerable 370	Considerable, light brown.

TABLE 1.—*Results of analyses of the waters of the reservoirs and storage basin*—Continued.

No. of sample.	Name of reservoir.	Date.	General characteristics.					
			Color.		Odor.	Turbidity.		Sediment.
		1906.						
196	Georgetown	Aug. 27	Yellowish brown	14	None	do	175	Slight, light brown.
192	Washington	Aug. 27	do	11	do	do	90	Do.
193	Storage basin	Aug. 27	Slight grayish	12	do	Slight	9	Very slight.
230	Dalecarlia, inlet	Sept. 4	Light yellowish brown		do	Considerable		Slight, light brown.
231	Dalecarlia, outlet	Sept. 4	do		do	do		Do.
234	Georgetown	Sept. 4	Brown		do	do		Do.
228	Washington	Sept. 4	Light yellowish brown		do	do		Very slight.
229	Storage basin	Sept. 4	do		do	Slight		None.
246	Dalecarlia inlet	Sept. 6	do	10	do	Less than formerly	45	Slight, light brown.
247	Dalecarlia, outlet	Sept. 6	do	11	do	>246	70	Do.
248	Georgetown	Sept. 6	do	12	do	Considerable	65	Do.
244	Washington	Sept. 6	do	8	do	do	80	Do.
245	Storage basin	Sept. 6	do	12	do	Slight	9	None.
260	Dalecarlia, inlet	Sept. 10	Very light brown	6	Slight woody	do	27	Slight, light brown.
261	Dalecarlia, outlet	Sept. 10	do	6	do	do	23	Very slight, light brown.
262	Georgetown	Sept. 10	do	7	Slight	do	9	Do.
263	Washington	Sept. 10	Light brown	9	None	do	45	None.
264	Storage basin	Sept. 10	Very slight	8	do	Very slight	2	Do.
276	Dalecarlia, inlet	Sept 13	Slight brown	7	Slight woody	Slight	16	Slight, light brown.
277	Dalecarlia, outlet	Sept. 13	do	6	do	Slight>276	23	Very slight, light brown.
278	Georgetown	Sept. 13	Light brown	7	do	Slight<277	18	Very slight.
279	Washington	Sept. 13	Slight, light brown	8	None	Slight	13	Slight, light brown.
280	Storage basin	Sept. 13	Practically none	8	do	Very slight	3	Very slight, light brown.
289	Dalecarlia, inlet	Sept. 17	Slight yellowish	3	do	Considerable	29	Slight, light brown.
290	Dalecarlia, outlet	Sept. 17	do	6	do	do	38	Do.
291	Georgetown	Sept. 17	do	4	do	do	24	Do.
292	Washington	Sept. 17	do	6	do	do	17	Very slight, light brown.
293	Storage basin	Sept. 17	do	6	do	Slight	4	None.

306	Dalecarlia, inlet	Sept. 20	Slight brown	9	Slight woody	.....do	23	Very slight, light brown.
307	Dalecarlia, outlet	Sept. 20	.....do	8	.....do	.....do	23	None.
308	Georgetown	Sept. 20	.....do	7	Very slight	.....do	23	Do.
309	Washington	Sept. 20	.....do	6	.....do	.....do	22	Do.
310	Storage basin	Sept. 20	Apparently none	6	None	Apparently none	2	Do.
319	Dalecarlia, inlet	Sept. 24	Light brown	10	Slight	Considerable	35	Slight, light brown.
320	Dalecarlia, outlet	Sept. 24	.....do	7	Slight, apparently due to algæ.	>319	45	Do.
321	Georgetown	Sept. 24	Slight brownish	7	.....do	Considerable	23	Very slight.
322	Washington	Sept. 24	Slight brown	8	Very slight	Slight	14	None.
323	Storage basin	Sept. 24	Apparently none	9	None	Apparently none	1	Do.
336	Dalecarlia, inlet	Sept. 27	Light brown		Slight woody	Slight		Very slight, light brown.
337	Dalecarlia, outlet	Sept. 27	.....do		.....do	.....do		Do.
338	Georgetown	Sept. 27	.....do		Slight	.....do		None.
339	Washington	Sept. 27	.....do		.....do	.....do		Do.
340	Storage basin	Sept. 27	Apparently none		None	Apparently none		Do.

TABLE 1.—*Results of analyses of the waters of the reservoirs and storage basins*—Continued.

No. of sample.	Name of reservoir.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												°C.		
63	Dalecarlia, inlet	161	98	63	Considerable charring, odor disagreeable, like burning hair.	2.85	0.030	0.081	0.0025	0.75	7.23	25.4	87.25	2.8
64	Dalecarlia, outlet	149	79	70	Considerable charring, odor quite disagreeable	2.95	.030	.079	.0045	.50	8.29	25.0	99.29	2.8
65	Georgetown	141	85	56	No charring, odor disagreeable, like burning wood.	2.85	.030	.071	.0090	.60	6.99	26.5	86.2	2.6
61	Washington	114	79	35	Considerable charring, odor like burning hair	2.75	.028	.061	.0063	.55	6.84	26.4	84.17	2.75
62	Storage basin	125	73	52	Some charring, odor like burning wood	2.85	.014	.028	.0003	.60	5.36	26.4	67.42	1.6
95	Dalecarlia, inlet	238	190	48	Considerable charring, odor of burning wood	2.3	.038	.268	.0030	.60	6.62	27.5	83.27	5.85
96	Dalecarlia, outlet	209	169	40	Marked charring, odor disagreeable	2.95	.046	.206	.0070	.70	6.66	28.0	84.52	5.0
97	Georgetown	163	120	43	Some charring, odor more or less disagreeable	3.04	.030	.142	.0114	.60	6.78	28.5	89.74	3.85
93	Washington	153	93	60	Some charring, odor very disagreeable	2.95	.022	.076	.0060	.50	7.88	26.6	97.46	2.3
94	Storage basin	135	86	49	Some charring, odor unpleasant	3.1	.024	.066	.0003	.63	6.38	27.0	79.45	1.5
122	Dalecarlia, inlet	271	233	38	Some charring, first of burning wood, then of burning feathers.	2.47	.047	.204	.0040	.40	7.85	26.5	96.8	5.85
123	Dalecarlia, outlet	163	125	38	Slight charring, odor fishy and like burning horn.	2.95	.028	.187	.0076	.42	7.31	26.5	90.13	3.7
124	Georgetown	148	91	57	Some charring, odor of burning wood, then disagreeable.	2.75	.030	.134	.0109	.65	7.31	27.0	91.03	3.35
125	Washington	140	88	52	Some charring, odor more or less disagreeable	2.75	.026	.155	.0095	.68	7.31	27.0	91.03	2.65
126	Storage basin	117	65	52	Some charring, odor disagreeable, like burning horn.	2.75	None.	.020	None.	.68	4.39	27.0	54.67	1.6
160	Dalecarlia, inlet	232	158	74	No charring, slight odor of burning wood	2.57	.039	.230	.0030	.75	7.47	26.5	92.16	4.11
161	Dalecarlia, outlet	174	91	83	Some charring, odor of burning wood	1.9	.030	.140	.0020	.55	7.43	26.5	91.61	3.56
162	Georgetown	150	112	38	Some charring, odor of burning wood, then disagreeable.	2.1	.032	.170	.0041	.55	7.8	26.5	96.3	3.11
165	Washington	131	90	41	Slight charring, odor of burning wood	2.3	.018	.159	.0050	.60	7.47	26.5	92.1	2.9
166	Storage basin	117	71	46	Slight charring, odor unpleasant	2.3	.014	.104	None.	.63	5.2	26.5	64.11	1.65
176	Dalecarlia, inlet	390?	306	84	Considerable charring, odor of burning wood	2.3	.032	.326	.0033	.50	5.12?	26.5	63.13	7.3
177	Dalecarlia, outlet	202	152	50	Considerable charring, odor disagreeable	2.6	.025	.142	.0031	.40	7.03	27.0	87.54	4.7

178	Georgetown	172	116	56	....do	2.3	.014	.132	.0035	.40	7.17	27.0	89.29	3.8
173	Washington	198	146	52	Some charring, odor disagreeable	2.2	.010	.096	.0042	.50	7.72	27.0	96.13	3.65
174	Storage basin	122	104	18	Some charring, odor considerable	2.4	.009	.030	None.	.55	5.24	27.0	65.25	1.45
194	Dalecarlia, inlet	430	191	239	Very little charring, odor disagreeable	2.2	.036	.410	.0050	.50	7.8	24.5	92.52	7.8
195	Dalecarlia, outlet	252	198	54	Some charring, odor disagreeable	2.2	.028	.229	.0095	.40	7.56	25.0	90.54	3.6
196	Georgetown	312	174	138	....do	2.5	.031	.150	.0080	.50	6.99	25.0	83.64	4.8
192	Washington	166	114	52	Some charring, odor that of burning wood	2.3	.030	.080	.0070	.50	7.23	25.5	87.21	4.0
193	Storage basin	118	66	52	Some darkening, odor of burning wood	2.4	.020	.058	.0005	.50	5.12	26.5	63.08	2.25
230	Dalecarlia, inlet	130	82	48	Considerable charring, odor disagreeable	2.47	.036	.125	.0025	.88	6.83	24.0	80.25	4.5
231	Dalecarlia, outlet	112	52	60	....do	2.1	.020	.198	.0040	.63	7.73	24.0	90.83	5.5
234	Georgetown	126	82	44	....do	2.5	.033	.126	.0100	.63	7.25	24.0	85.19	4.3
228	Washington	110	64	46	Some charring, odor disagreeable	1.9	.028	.114	.0100	.50	7.02	24.0	62.49	5.3
229	Storage basin	136	110	26	Considerable charring, odor of burning wood	1.9	.024	.072	Trace.	.63	......	......	......	3.5
246	Dalecarlia, inlet	131	102	29	Some charring, odor disagreeable	2.4	.006	.106	.0020	.75	8.18	22.0	92.53	3.1
247	Dalecarlia, outlet	126	87	39	Some charring, odor very disagreeable, like burning horn.	2.6	.026	.133	.0035	.75	7.95	22.5	90.75	3.2
248	Georgetown	126	87	39	Some charring, odor disagreeable	2.6	.032	.118	.0055	.63	7.77	23.0	89.62	3.8
244	Washington	120	79	41	Considerable charring, some disagreeable odor	2.6	.024	.142	.0080	.63	7.25	23.0	83.62	4.4
245	Storage basin	95	67	28	Considerable charring, odor disagreeable	2.3	.012	.070	None.	.75	5.59	23.0	64.47	3.3
260	Dalecarlia, inlet	156	138	18	Slight charring, odor of burning wood	2.2	.008	.100	.0014	.60	8.0	25.5	96.50	2.25
261	Dalecarlia, outlet	172	138	24	Some darkening, odor disagreeable	2.3	.006	.080	.0030	.63	9.25	24.5	97.98	2.5
262	Georgetown	172	150	22	Some darkening, odor of burning wood, disagreeable.	2.3	None.	.128	.0033	.65	9.59	24.0	100.9	2.7
263	Washington	166	140	26	Some charring, odor disagreeable	2.	.004	.096	.0032	.70	8.11	24.0	95.3	3.0
264	Starage basin	166	114	52	Some charring, odor of burning wood disagreeable.	2.0	.012	.046	.0002	.75	6.11	24.0	71.79	2.8
276	Dalecarlia, inlet	128	99	39	Some charring, odor disagreeable	2.3	.012	.074	.0014	.50	7.7	27.0	95.89	2.0
277	Dalecarlia, outlet	128	93	35	Some charring, odor quite disagreeable	2.4	.004	.072	.0014	.63	8.26	26.5	101.7	2.0
278	Georgetown	123	83	40	Some charring, odor markedly disagreeable	2.2	.010	.088	.0016	.63	7.95	26.0	97.07	2.2
279	Washington	120	84	36	Some charring, odor disagreeable	2.2	.008	.074	.0014	.70	7.90	25.0	94.61	2.5
280	Storage basin	110	76	34	Some charring, odor disagreeable	2.2	.012	.032	None.	.75	6.75	25.0	82.03	1.7
289	Dalecarlia, inlet	139	100	39	Slight darkening, slight disagreeable odor	3.1	.022	.092	.0054	.63	8.94	23.0	103.1	2.7
290	Dalecarlia, outlet	162	130	32	....do	2.85	.034	.092	.0134	.63	7.73	23.0	89.16	2.5
291	Georgetown	182	167	15	Some darkening, slight disagreeable odor	2.6	.014	.094	.0052	.75	7.24	23.0	83.50	2.4
292	Washington	160	139	21	Considerable charring, odor of burning wood	2.66	.008	.084	.0044	.65	8.22	25.0	94.80	2.2
293	Storage basin	151	124	27	Some charring, odor of burning wood	2.66	.032	.078	.0018	.80	6.15	25.0	73.65	1.9

TABLE 1.—*Results of analyses of the waters of the reservoirs and storage basins*—Continued.

No. of sample.	Name of reservoir.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												°C.		
306	Dalecarlia, inlet	145	100	45	Very slight charring, some disagreeable odor	2.95	.018	.094	.0023	.60	7.53	26.0	91.95	2.5
307	Dalecarlia, outlet	145	101	44	Slight darkening, some disagreeable odor	3.04	.040	.108	.0020	.63	7.25	25.0	86.82	2.5
308	Georgetown	141	97	44	Some charring, somewhat disagreeable odor	3.2	.016	.066	.0062	.65	7.39	24.0	86.83	2.5
309	Washington	127	95	32	Some charring, slight disagreeable odor	2.47	.008	.082	.0050	.70	7.98	25.0	95.57	2.0
310	Storage basin	122	96	26	Considerable charring, odor disagreeable	2.95	.004	.044	Trace.	.75	7.87	25.0	94.25	1.6
319	Dalecarlia, inlet	126	103	23	Some charring, odor disagreeable, like burning horn.	2.95	.012	.098	.0038	.60	......	26.5	......	2.05
320	Dalecarlia, outlet	135	107	28	Some charring, odor of burning wood, then of burning horn.	2.95	018	.092	.0050	.63	......	25.0	......	2.15
321	Georgetown	130	101	29	More charring than 319 and 320, odor somewhat disagreeable.	2.95	.022	.138	.0050	.65	......	26.0	......	2.4
322	Washington	120	91	29	Some charring, odor of burning wood, then disagreeable.	2.66	.004	.064	.0040	.70	7.91	25.0	94.73	1.8
323	Storage basin	118	89	29	.....do	2.6	.004	.031	.0008	.75	6.32	25.0	75.70	1.1
336	Dalecarlia, inlet	157	93	64	Slight charring, odor somewhat disagreeable	3.3	.006	.066	.0030	.50	......	21.0	......	......
337	Dalecarlia, outlet	158	89	69	No charring, odor somewhat disagreeable	2.75	.036	.079	.0058	.50	......	23.0	......	......
338	Georgetown	153	86	67	Some charring, odor somewhat disagreeable	2.75	.008	.076	.0068	.55	......	23.0	......	......
339	Washington	145	91	54	Some charring, odor of burning wood, then somewhat disagreeable.	2.85	.024	.056	.0037	.60	......	24.0	......	......
340	Storage basin	142	85	57	Slight darkening, odor slightly disagreeable	3.04	.002	.072	None.	.65	......	23.5	......	......

TABLE 2.—*Results of analyses of the waters of the reservoirs and storage basin, so arranged as to show the average composition of these waters, for the period covered by this investigation (July 30 to September 27, 1906).*

Name of reservoir.	No. of sample.	Date.	General characteristics. Color.		Odor.	Turbidity.		Sediment.
		1906.						
Analyses of water from Dalecarlia reservoir, inlet.	63	July 30	Yellowish brown	......	Earthy and woody	Great>64	......	Large>64.
	95	Aug. 7	Yellowish brown>96	......	Woody	Great	......	
	122	Aug. 13	Yellowish brown	......	Earthy	....do	......	Heavy yellowish brown.
	160	Aug. 21	Slight	9	None	Considerable	......	Considerable, brown, heavy.
	176	Aug. 23	Dark brown	......	Earthy	Very great	650	Heavy, brown, like clay.
	194	Aug. 27	Brown	12	None	Great	775	Heavy, considerable, like clay.
	230	Sept. 4	Light yellowish brown	......	....do	Considerable	......	Slight, light brown.
	246	Sept. 6	....do	10	....do	Less than formerly	......	Do.
	260	Sept. 10	Very light brown	6	Slight woody	Slight	27	Do.
	276	Sept. 13	Slight brown	7	....do	....do	16	Do.
	289	Sept. 17	Slight yellowish	3	None	Considerable	20	Do.
	306	Sept. 20	Slight brown	9	Slight woody	Slight	23	Very slight, light brown.
	319	Sept. 24	Light brown	10	Slight	Considerable	35	Slight, light brown.
	336	Sept. 27	....do	......	Slight woody	Slight	......	Very slight, light brown.
Average	......	......	Yellowish brown to dark brown.	8.2	......	......	221	
Analyses of water from Dalecarlia reservoir, outlet.	64	July 30	Yellowish brown	......	Earthy and woody<63	Considerable<63>65	......	Considerable<63>65.
	96	Aug. 7	Yellowish brown<95	......	Woody, earthy>95	Great<95	......	
	123	Aug. 13	Yellowish brown<122	......	Earthy<122	Great<122	......	Heavy<122.
	161	Aug. 21	Slight	14	None	Considerable	......	Slight.
	177	Aug. 23	Light brown	......	Slight earthy	....do	200	Fine, brown.
	195	Aug. 27	....do	14	None	....do	370	Considerable, light brown.
	231	Sept. 4	Light yellowish brown	......	....do	....do	......	Slight, light brown.
	247	Sept. 6	....do	......	....do	Greater than 246	70	Do.
	261	Sept. 10	Very light brown	6	Slight woody	Slight	23	Very slight, light brown.
	277	Sept. 13	Slight brown	6	....do	Slight>276	23	Do.

TABLE 2.—*Results of analyses of the waters of the reservoirs and storage basin, etc.*—Continued.

Name of reservoir.	No. of sample.	Date.	General characteristics. Color.		Odor.	Turbidity.		Sediment.
		1906.						
Analyses of water from Dalecarlia reservoir, outlet.	290	Sept. 17	Slight yellowish	6	None	Considerable	38	Slight, light brown.
	307	Sept. 20	Slight brown	8	Slight woody	Slight	23	None.
	320	Sept. 24	Light brown	7	Slight, apparently due to algæ.	Greater than 319	45	Slight, light brown.
	337	Sept. 27	do		Slight woody	Slight		Very slight, light brown.
Average			Slight yellowish to yellowish brown.	8.7			99	
Analyses of water from Georgetown reservoir.	65	July 30	Yellowish		Earthy and woody<63=64.	Considerable<64>65.		Considerable<64.
	97	Aug. 7	Yellowish brown<96		Woody, earthy>96	Considerable<96.		
	124	Aug. 13	Yellowish<123		Earthy<123	Considerable<123		Considerable<123.
	162	Aug. 21	Slight	10	None	Considerable		Slight.
	178	Aug. 23	Yellowish		Very slight earthy	do	105	Fine, brown.
	196	Aug. 27	Yellowish brown	14	None	do	175	Slight, light brown.
	234	Sept. 4	Brown		do	do		Do.
	248	Sept. 6	Light yellowish brown	12	do	do	65	Do
	262	Sept. 10	Very light brown	7	Slight	Slight	9	Very slight, light brown.
	278	Sept. 13	Light brown	7	Slight woody	Slight<277	18	Very slight.
	291	Sept. 17	Slight yellowish	4	None	Considerable	24	Slight, light brown.
	308	Sept. 20	Slight brown	7	Very slight	Slight	23	None.
	321	Sept. 24	Slight brownish	7	Slight, apparently due to algæ.	Considerable	23	Very slight.
	338	Sept. 27	Light brown		Slight	Slight		None.
Average			Slight yellowish to yellowish brown.	8.5			55.2	
Analyses of water from Washington reservoir.	61	July 30	Slight yellowish		Slightly earthy	Slight<65		Slight, much less than 65.
	93	Aug. 7	Yellowish		Very distinctly woody	Considerable<97>94.		None.
	125	Aug. 13	Slight	12	Slight earthy	Slight		Slight, yellowish.

	165	Aug. 21	do	11	None	Considerable		None.
	173	Aug. 23	Yellowish brown	11	do	do	90	Slight, brownish.
	192	Aug. 27	Light yellowish brown		do	do	90	Very light brown.
	228	Sept. 4	Brown		do	do		Very slight.
	244	Sept. 6	Light yellowish brown	8	do	do	80	Slight, light brown.
	263	Sept. 10	Light brown	9	do	Slight	45	None.
	279	Sept. 13	Slight, light brown	8	do	do	13	Slight, light brown.
	292	Sept. 17	Slight yellowish	6	do	do	17	Very slight, light brown.
	309	Sept. 20	Slight brown	6	Very slight	do	22	None.
	322	Sept. 24	do	8	do	do	14	Do.
	339	Sept. 27	Light brown		Slight	do		Do.
Average			Slight yellowish to brown	8.7			46.3	
Analyses of water from storage basin.	62	July 30	Very slight		None	Very slight		None.
	94	Aug. 7	do		Woody	do		Do.
	126	Aug. 13	do		None	Practically none		Do.
	166	Aug. 21	Slight	9	do	Slight		Do.
	174	Aug. 23	do	7	do	do	7	Do.
	193	Aug. 27	Slight grayish	12	do	do	9	Very slight.
	229	Sept. 4	Light yellowish brown		do	do		None.
	245	Sept. 6	do	12	do	do	9	Do.
	264	Sept. 10	Very slight	8	do	Very slight	2	Do.
	280	Sept. 13	Practically none	8	do	do	3	Very slight, light brown.
	293	Sept. 17	Slight yellowish	6	do	Slight	4	None.
	310	Sept. 20	Apparently none	6	do	Apparently none	2	Do.
	323	Sept. 24	do	9	do	do	1	Do.
	340	Sept. 27	do		do	do		Do.
Average			Practically none to light yellowish brown.	8.5			4.6	

TABLE 2.—*Results of analyses of the waters of the reservoirs and storage basin, etc.*—Continued.

Name of reservoir.	No. of sample.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° C.		
Analyses of water from Dalecarlia reservoir, inlet.	63	161	98	63	Considerable charring, odor disagreeable, like burnt hair.	2.85	0.030	0.081	0.0025	0.75	7.23	25.4	87.25	2.8
	95	238	190	48	Considerable charring, odor of burning wood ..	2.3	.038	.268	.0030	.60	6.62	27.5	83.27	5.85
	122	271	233	38	Some charring, first of burning wood, then of burning feathers.	2.47	.047	.204	.0040	.40	7.85	26.5	96.8	5.85
	160	232	158	74	No charring, slight odor of burning wood......	2.57	.039	.230	.0030	.75	7.47	26.5	92.16	4.11
	176	390?	306	84	Considerable charring, odor of burning wood ..	2.3	.032	.326	.0033	.50	5.12?	26.5	63.13	7.3
	194	430	382	48	Very little charring, odor disagreeable.........	2.2	.036	.410	.0050	.50	7.8	24.5	92.52	7.8
	230	130	82	48	Considerable charring, odor disagreeable.......	2.47	.036	.125	.0025	.88	6.83	24.0	80.25	4.5
	246	131	102	29	Some charring, odor disagreeable..............	2.4	.006	.106	.0020	.75	8.18	22.0	92.53	3.1
	260	156	138	18	Slight charring, odor of burning wood.........	2.2	.008	.100	.0014	.60	8.0	25.5	96.50	2.25
	276	128	99	39	Some charring, odor disagreeable..............	2.3	.012	.074	.0014	50	7.7	27.0	95.89	2.0
	289	139	100	39	Slight, darkening, slight disagreeable odor.....	3.1	.022	.092	.0054	.63	8.94	23.0	103.1	2.7
	306	145	100	45	Very slight charring, some disagreeable odor ..	2.95	.018	.094	.0023	.60	7.53	26.0	91.95	2.5
	319	126	103	23	Some charring, odor disagreeable like burning horn.	2.95	.012	.098	.0038	.60	......	26.5	......	2.05
	336	157	93	64	Slight charring, odor somewhat disagreeable...	3.3	.006	.066	.0030	.50	......	21.5	......	......
Average..............	......	203	156	47.1	....	2.6	.024	.161	.0031	.61	7.44	......	89.6	4.1
Analyses of water from Dalecarlia reservoir, outlet.	64	149	79	70	Considerable charring, odor quite disagreeable..	2.95	.030	.079	.0045	.50	8.29	25.0	99.29	2.8
	96	209	169	40	Marked charring, odor disagreeable............	2.95	.046	.206	.0070	.70	6.66	28.0	84.52	5.0
	123	163	125	38	Slight charring, odor fishy, like burning horn..	2.95	.028	.187	.0076	.42	7.31	26.5	90.13	3.7
	161	174	91	83	Some charring, odor of burning wood..........	1.9	.030	.140	.0020	.55	7.43	26.5	91.61	3.56
	177	202	152	50	Considerable charring, odor disagreeable.......	2.6	.025	.142	.0031	.40	7.03	27.0	87.54	4.7
	195	252	198	54	Some charring, odor disagreeable..............	2.2	.028	.229	.0095	.40	7.56	25.0	90.54	3.6
	231	112	52	60	Considerable charring, odor disagreeable.......	2.1	.020	.198	.0040	.63	7.73	24.0	90.83	5.5
	247	126	87	39	Some charring, odor very disagreeable, like burnt horn.	2.6	.026	.133	.0035	.75	7.95	22.5	90.75	3.2

	261	172	138	24	Some darkening, odor disagreeable	2.3	.006	.080	.0030	.63	8.25	24.5	97.98	2.5
	277	128	93	35	Some charring, odor quite disagreeable	2.4	.004	.072	.0014	.63	8.26	26.5	101.7	2.0
	290	162	130	32	Slight darkening, slight disagreeable odor	2.85	.034	.092	.0134	.63	7.73	23.0	89.16	2.5
	307	145	101	44	Slight darkening, some disagreeable odor	3.04	.040	.108	.0020	.63	7.25	25.0	86.82	2.5
	320	135	107	28	Some charring, odor of burnt wood, then of burnt horn.	2.95	.018	.092	.0050	.63	......	25.0	......	2.15
	337	158	89	69	No charring, odor somewhat disagreeable	2.75	.036	.079	.0058	.50	......	23.0	......	......
Average	......	163	115	48	......	2.61	.027	.131	.0051	.57	7.62	......	92.4	3.4
Analyses of water from Georgetown reservoir.	65	141	85	56	No charring, odor disagreeable like burning wood.	2.85	.030	.071	.0090	.60	6.99	26.5	86.2	2.6
	97	163	120	43	Some charring, odor more or less disagreeable	3.04	.030	.142	.0114	.60	6.78	28.5	89.74	3.85
	124	148	91	57	Some charring, odor of burning wood, then disagreeable.	2.75	.030	.134	.0109	.65	7.31	27.0	91.03	3.35
	162	150	112	38	....do	2.1	.032	.170	.0041	.55	7.8	26.5	96.33	3.11
	178	172	116	56	Considerable charring, odor disagreeable	2.3	.014	.132	.0035	.40	7.17	27.0	89.29	3.8
	196	312	174	138	Some charring, odor disagreeable	2.5	.031	.150	.0080	.50	6.99	25.0	83.64	4.8
	234	126	82	44	Considerable charring, odor disagreeable	2.5	.033	.126	.0100	.63	7.25	24.0	85.19	4.3
	248	126	87	39	Some charring, odor disagreeable	2.6	.032	.118	.0055	.63	7.77	23.0	89.62	3.8
	262	172	150	22	Some darkening, odor of burnt wood, disagreeable.	2.3	None.	.128	.0033	.65	8.59	24.0	100.9	2.7
	278	123	83	40	Some charring, odor markedly disagreeable	2.2	.010	.088	.0016	.63	7.95	26.0	97.07	2.2
	291	182	167	15	Some darkening, slight disagreeable odor	2.6	.014	.094	.0052	.75	7.24	23.0	83.50	2.4
	308	141	97	44	Some charring, somewhat disagreeable odor	3.2	.016	.066	.0062	.65	7.39	24.0	86.83	2.5
	321	130	101	29	More charring than 319 and 320, odor somewhat disagreeable.	2.95	.022	.138	.0050	.65	......	26.0	......	2.4
	338	153	86	67	Some charring, odor somewhat disagreeable	2.75	.008	.076	.0068	.55	......	23.0	......	......
Average	......	160	111	49	......	2.61	.022	.117	.0065	.60	7.44	......	90.0	3.3
Analyses of water from Washington reservoir.	61	114	79	35	Considerable charring, odor like burning hair	2.75	.028	.061	.0063	.55	6.84	26.4	84.17	2.75
	93	153	93	60	Some charring, odor very disagreeable	2.95	.022	.076	.0060	.50	7.88	26.6	97.46	2.3
	125	140	88	52	Some charring, odor more or less disagreeable	2.75	.026	.155	.0095	.68	7.31	27.0	91.03	2.65
	165	131	90	41	Slight charring, odor of burning wood	2.3	.018	.159	.0050	.60	7.47	26.5	92.1	2.9
	173	198	146	52	Some charring, odor disagreeable	2.2	.010	.096	.0042	.50	7.72	27.0	96.13	3.65
	192	166	114	52	Some charring, odor that of burning wood	2.3	.030	.080	.0070	.50	7.23	25.5	87.21	4.0

TABLE 2.—*Results of analyses of the waters of the reservoirs and storage basin, etc.*—Continued.

Name of reservoir.	No. of sample.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° C.		
Analyses of water from Washington reservoir.	228	110	64	46	Some charring, odor disagreeable	1.9	.028	.114	.0100	.50	7.02	24.0	62.49	5.3
	244	120	79	41	Considerable charring, some disagreeable odor.	2.6	.024	.142	.0080	.63	7.25	23.0	83.62	4.4
	263	166	140	26	Some charring, odor disagreeable	2.0	.004	.096	.0032	.70	8.11	24.0	95.3	3.0
	279	120	84	36	.....do	2.2	.008	.074	.0014	.70	7.90	25.0	94.61	2.5
	292	160	139	21	Considerable charring, odor of burning wood	2.66	.008	.084	.0044	.65	8.22	23.0	94.8	2.2
	309	127	95	32	Some charring, slight disagreeable odor	2.47	.008	.082	.0050	.70	7.98	25.0	95.57	2.0
	322	120	91	29	Some charring, odor of burnt wood, then disagreeable.	2.66	.004	.064	.0040	.70	7.91	25.0	94.73	1.8
	339	145	91	54	Some charring, odor of burning wood, then somewhat disagreeable.	2.85	.024	.056	.0037	.60	......	24.0	......	......
Average	......	141	100	41	......	2.47	.017	.096	.0056	.61	7.60	......	90.0	3.0
Analyses of water from storage basin.	62	125	73	52	Some charring, odor like burning wood	2.85	.014	.028	.0003	.60	5.36	26.4	67.42	1.6
	94	135	86	49	Some charring, odor unpleasant	3.1	.024	.066	.0003	.63	6.38	27.0	79.45	1.5
	126	117	65	52	Some charring, odor disagreeable, like burning horn.	2.75	None.	.020	None.	.68	4.39	27.0	54.67	1.6
	166	117	71	46	Slight charring, odor unpleasant	2.3	.014	.104	None.	.63	5.2	26.5	64.11	1.65
	174	122	104	18	Some charring, odor considerable	2.4	.009	.030	None.	.55	5.24	27.0	65.25	1.45
	193	118	66	52	Some darkening, odor of burning wood	2.4	.020	.058	.0005	.50	5.12	26.5	63.08	2.25
	229	136	110	26	Considerable charring, odor of burning wood	1.9	.024	.072	Trace.	.63	......	......	......	3.5
	245	95	67	28	Considerable charring, odor disagreeable	2.3	.012	.070	None.	.75	5.59	23.0	64.47	3.3
	264	166	114	52	Some charring, odor of burning wood, disagreeable.	2.0	.012	.046	.0002	.75	6.11	24.0	71.79	2.8
	280	110	76	34	Some charring, odor disagreeable, less than unfiltered.	2.2	.012	.032	None.	.75	6.75	25.0	82.03	1.7
	293	151	124	27	Some charring, odor of burning wood	2.66	.032	.078	.0018	.80	6.15	25.0	73.65	1.9
	310	122	96	26	Considerable charring, odor disagreeable	2.95	.004	.044	Trace.	.75	7.87	25.0	94.25	1.6

	323	118	89	29	Some charring, odor of burning wood, then disagreeable.	2.6	.004	.031	.0008	.75	6.32	25.0	75.70	1.1
	340	142	85	57	Slight darkening, odor slightly disagreeable....	3.04	.002	.072	None.	.65	......	23.5	......	......
Average...............	......	127	88	39	....	2.53	.015	.054	.0003	.67	5.87	......	71.4	2.0

TABLE 3.—*Results of analyses of the water of the Potomac River by several investigators.*

Investigator.	Total solids.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Required oxygen.
			Free.	Albuminoid.			
Not given; Potomac water, 1904-5 [a]	146.1	5.23	0.073	0.229	0.0054	1.16	1.72
Health office, 1897-1900 [a]	126.7	3.78	.0008	.111	Trace.	.639	2.56
Office of Surgeon-General, 1899 [a]	125.0	4.0	Trace.	.150	Trace.	1.10	2.10
R. S. Weston [a]	139.0	2.60	.013	.105	.002	.73	4.50
Laboratory of filtration plant, F. F. Longley	......	2.0	.032	.244	.0033	.79	....
Hygienic laboratory, division of chemistry	203.0	2.81	.024	.161	.0031	.61	4.1
Mason, "Water Supply" (1894)	165.0	1.1	.050	.127	Trace.	.23	1.021

[a] From "The Potomac River Basin" Water-Supply Paper No. 192, U. S. Geological Survey, by Horatio M. Parker.

TABLE 4.—*Showing extreme variation in the chemical composition of the water of the Potomac.*

Year.	Source of data.	Suspended solids.	Turbidity.	Total solids.			Chlorine.
				Total residue.	Mineral matter.	Volatile matter.	
1889	Report on typhoid fever in the District of Columbia (1894)	....	....	270 76	....	....	5.0 3.5
1906	Captain Cosby's report, analyses from Feb. 20 to June 26	846 7	1,000 10	....	....	....	3.2 0.8
1906	Hygienic laboratory (division of chemistry) analyses from July 30 to Sept. 27	....	775 16	430 126	382 82	84 18	3.3 2.2

Year.	Source of data.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
		Free.	Albuminoid.					
1889	Report on typhoid fever in the District of Columbia (1894)	0.3920 .0000	0.6520 .0600	Trace. 0.000	0.8 .50	....	....	3.80 .88
1906	Captain Cosby's report, analyses from Feb. 20 to June 26	.100 .009	.556 .090	.0070 Trace.	1.10 .05	....	....	....
1906	Hygienic Laboratory (division of chemistry) analyses from July 30 to Sept. 27	.047 .006	.410 .066	.0054 .0014	.88 .40	8.94 5.12	103.1 63.1	7.8 2.0

TABLE 5.—*Chemical analyses of Potomac water, yearly average for five years (1888–1893).*

[Compiled from Report on Typhoid Fever in the District of Columbia, Washington, 1894, Table V, p. 8.]

Year.	Total solids.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Oxygen consumed.
			Free.	Albuminoid.			
1888	111	4.2	0.0170	0.1190	0.000	0.97	1.98
1889	110	4.2	.0190	.2140	.000	.82	1.82
1889-90	136	4.3	.041	.295	.000	.70	1.85
1890-91	104	4.3	.0043	.0627	.000	.60	1.97
1891-92	113	4.3	Trace.	.064	.000	.60	1.85
1892-93	125	4.7	.0200	.0661	.000	.60	1.64

According to this report (p. 8), "The Potomac water has been subject to very careful analyses" and "in general the water may be said to be in excellent condition and to compare extremely favorably * * * with that of other cities." Its chief defect is the presence of suspended clay in the winter and after heavy rains in any season.

TABLE 6.—*Analyses of city water supplies.*

City.	Source of supply.	Ammonia.		Chlorine.	Nitrites.	Nitrates.	Oxygen consumed.	Total residue.
		Free.	Albuminoid.					
Poughkeepsie, N. Y. [a]	Hudson River	0.050	0.125	4.5	Trace.	Trace.	2.287	85.0
Washington, D. C. [a]	Potomac River	.050	.127	1.1	Trace.	0.230	1.021	165.0
Richmond, Va. [a]	James River	.550	.150	1.17	Trace.	Trace.	1.654	105.0
Rock Island, Ill. [a]	Mississippi River	.025	.260	1.00	0	Trace.	6.000	140.0
New Orleans, La. [a]	do	.040	.325	14.50	0	.080	5.724	340.0
Cincinnati, Ohio [a]	Ohio River	.003	.108	14.0	....	.26	....	140.0
Louisville, Ky. (before filtration). [b]	do	.034	.530	6.2	0.004	1.0	9.90	800.0
Louisville, Ky. (after filtration). [b]	do	.085	.130	5.78	.0085	.5	1.5	255.0
Philadelphia, Pa. [a]	Schuylkill River	.010	.100	....	0	.46	....	133.4
Albany, N. Y. [a]	Hudson River	.070	.200	2.5	Trace.	.082	5.7	....
Troy, N. Y. [a]	do	.040	.150	2.5	0	.041	8.4	....
Cohoes, N. Y. [a]	Mohawk River	.060	.210	4.0	.002	.246	3.55	....

[a] Mason, "Water Supply," New York, 2d ed., 1898, p. 465.
[b] Fuller, "Water Purification at Louisville," New York, 1898, pp. 197-204.

TABLE 7.—*Results of the analyses of the water of taps and hydrants, July 16 to September 28, 1906.*

No. of sample.	Location.	Date.	General characteristics. Color.	Odor.	Turbidity.	Sediment.
		1906.				
2	1112 Tenth street NW	July 16	Very slight yellowish	None	Very slight	None.
4	3 F street NW	do	Very slight greenish yellow	do	do	Do.
7	1523 Seventh street NW	July 17	Very faint yellowish	do	do	Do.
10	811 Thirteenth street NW	do	do	do	do	Do.
12	25 Defrees street NW	July 18	Slightly yellowish	do	do	Do.
16	1706 Twelfth street NW	do	Very slightly yellowish	do	Slight opalescence	Do.
19	442 N street NW	July 19	do	do	Very slight	Do.
20	448 O street NW	do	Very slight yellowish	do	do	Slight.
22	2 Thomas circle NW	do	do	do	Slight	Very slight.
25	643½ Third street NE	July 20	Slightly yellowish	do	do	None.
27	516 D street NE	do	do	do	do	Do.
31	909 Fourth street SE	July 23	Greenish yellow	Slight earthy	Very slight	Do.
33	607 E street SE	do	Yellow	Distinctly earthy	do	Do.
39	115 Eleventh street NE	July 24	Slightly yellowish	None	do	Do.
41	235 C street SW	do	Very slight yellowish	do	do	Do.
43	1531 Thirty-fifth street NW	July 25	Distinctly yellowish	do	Considerable	Do.
47	2900 P street NW	do	do	Slightly disagreeable	do	Some.
49	20 Seventh street SE	July 26	Very slight yellowish	None	Very slight	None.
50	808 East Capitol street	do	Very slight yellow	do	do	Very slight reddish particles.
51	537 Kentucky avenue SE	do	Nearly colorless	do	do	None.
52	415 Delaware avenue SW	do	Very slight yellow	do	do	Do.
54	1003 E street SW	do	Very slight yellowish	do	do	Do.
55	1215 Potomac street NW	July 27	do	do	do	Do.
56	1302 Thirty-sixth street NW	do	Faintly yellowish	Slightly disagreeable	do	Do.
59	1522 Twenty-sixth street NW	do	Very nearly none	None	do	Do.
60	2814 Pennsylvania avenue NW.	do	Very faint y llowish	Slightly woody	do	Do.
66	1432 Thirty-sixth street NW.	July 31	Practically none	None	None	Do.
68	1301 Thirtieth street NW	do	Slightly yellowish	Slightly woody	Very slight	Do.

69	1243 Thirtieth street NW	do	Very slight yellowish	None	do	Very slight yellowish brown particles.
70	1023 Twenty-sixth street NW	do	Nearly colorless	Slightly woody	do	Very slight dark particles.
73	412 L street NW	Aug. 1	Very light yellowish	None	do	None.
74	1906 Eleventh street NW	do	Very faint yellowish	Distinctly woody	do	Do.
75	1115 Union court NW	do	do	Slightly woody	do	Do.
76	2125 L street NW	do	do	Woody	do	Do.
78	1667 Euclid street NW	Aug. 2	Very slight yellow	None	do	Do.
79	1872 V street NW	do	Slightly yellow	do	Slight	Do.
80	2841 Florida avenue NW	do	Trace of yellow	do	Trace	Do.
81	2142 K street NW	do	Very slight yellowish	Distinctly woody	Very slight	Do.
82	1219 Twenty-ninth street NW	Aug. 3	do	None	do	Very slight.
83	3267 N street NW	do	do	do	Slight	Slight.
84	3616 P street NW	do	Very slightly yellowish	do	Very slight	None.
85	1511 Thirty-fourth street NW	do	Very slight yellowish	do	do	Do.
86	2820 P street NW	do	do	Very slight woody	do	Do.
90	1621 Minnesota avenue, Anacostia.	Aug. 6	do	Slight woody	None	Do.
345	Garnett School, Tenth and W streets NW.	Sept. 28	do	None	Very slight	Do.
346	Business High School, Ninth street NW.	do	Apparently none	do	do	Do.
347	Garrison, Twelfth street NW	do	do	do	do	Do.
348	Fountain, Iowa circle	do	do	do	Apparently none	Do.
349	Sumner School, Seventeenth and N streets NW.	do	do	do	Very slight	Do.

TABLE 7.—*Results of the analyses of the water of taps and hydrants, July 16 to September 28, 1906*—Continued.

No. of sample.	Location.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed
		Total.	Mineral matter	Volatile matter.			Free.	Albuminoid						
												C.°		
2	1112 Tenth street NW	128	83	45	Some blackening, odor somewhat disagreeable.	2.85	0.016	0.048	Trace.	0.75	......	......	......	2.3
4	3 F street NW	133	83	50	Some charring, odor burning feathers	2.85	.020	.048	Trace.	.85	......	......	......	2.3
7	1523 Seventh street NW	126	82	44	Slight charring, no odor	2.57	.016	.034	0.0003	.45	......	......	......	2.3
10	811 Thirteenth street NW	123	76	47	Some charring, no odor	2.66	.014	.048	.0003	.70	......	......	......	2.3
12	25 Defrees street NW	113	75	38	Some charring, odor of burning wood	2.57	.008	.040	None.	.65	......	......	......	2.25
16	1706 Twelfth street NW	119	71	48	Some charring, odor of burning pine wood	2.09	.008	.034	None.	.55	......	......	......	2.05
19	442 N street NW	122	68	54	Some charring, odor resinous	2.57	.016	.034	.0003	.55	7.29	27.0	90.78	2.05
20	448 O street NW	129	73	56	Some charring, odor resinous and disagreeable.	1.33	.014	.038	.0003	.50	7.71	26.5	95.25	2.00
22	2 Thomas circle NW	112	64	48	Some charring, odor more or less disagreeable.	2.47	.008	.024	.0004	.60	7.15	25.0	85.62	2.00
25	643½ Third street NE	130	69	61	Slight charring, odor of burning wood	1.62	.016	.036	None.	.55	6.63	26.5	81.92	1.95
27	516 D street NE	119	67	52	Slight charring, odor resinous	2.05	.014	.024	None.	.60	6.5	26.5	80.30	2.15
31	909 Fourth street SE	103	56	47	Some charring, odor of burning wood	2.66	.018	.038	None.	.50	6.7	27.0	83.43	2.2
33	607 E street SE	110	56	54	.....do	2.76	.006	.033	None.	.60	6.5	27.0	80.94	1.8
39	115 Eleventh street NE	126	70	56	.....do	2.85	.010	.040	None.	.75	6.54	26.5	80.81	2.25
41	235 C street SW	114	71	43	.....do	2.66	.018	.061	None.	.60	6.62	26.5	81.78	2.5
43	1531 Thirty-fifth street NW	135	75	60	.....do	2.85	.004	.034	None.	.70	6.44	26.5	72.02	2.05
47	2900 P street NW	141	83	58	Some charring, odor resinous	2.85	.004	.052	None.	.63	8.86	26.5	109.47	1.45
49	20 Seventh street SE	129	68	61	Some charring, odor of burning wood, and disagreeable.	2.3	.018	.011	.0003	.70	7.15	26.5	88.33	2.7
50	808 East Capitol street	132	65	67	Some charring, odor of burning wood	2.6	.005	.045	Trace.	.65	6.09	26.5	75.24	2.3
51	537 Kentucky avenue SE	130	75	55	Slight charring, odor disagreeable	2.4	.018	.027	.0003	.65	6.17	25.5	74.61	2.5
52	415 Delaware avenue SW	136	71	65	Some charring, odor of burning wood	2.3	.006	.027	Trace.	.63	6.17	27.0	76.84	2.95
54	1093 E street SW	130	72	58	.....do	2.6	.006	.041	Trace.	.55	6.04	27.0	75.21	2.06
55	1215 Potomac street NW	125	61	64	.....do	2.75	.014	.051	Trace.	.75	5.40	27.0	67.24	2.08
56	1302 Thirty-sixth street NW	126	66	60	.....do	2.66	.005	.029	None.	.75	5.52	26.5	68.21	2.22
59	1522 Twenty-sixth street NW	......	......	......	......	2.5	.010	.031	None.	.75	5.44	25.0	65.15	2.28

60	2814 Pennsylvania avenue NW.	131	68	63	Some charring, odor of burning wood	1.33	.008	.033	None.	.75	5.69	27.0	70.85	2.28
66	1432 Thirty-sixth street NW.	112	93	19	Some charring, odor resinous	2.66	.018	.020	.0001	.65	5.44	27.0	67.74	1.65
68	1301 Thirtieth street NW	126	76	50	Some charring, odor somewhat disagreeable	2.85	.018	.029	.0001	.55	5.77	27.0	71.85	1.55
69	1243 Thirtieth street NW	120	62	57	Some charring, odor of burning wood	2.85	.018	.033	.0001	.63	5.24	26.0	65.20	1.45
70	1023 Twenty sixth street NW	118	65	53	do	2.75	.016	.023	.0001	.75	5.44	26.5	67.21	1.75
73	412 L street NW	122	82	40	Some charring, odor of burning wood, and disagreeable.	2.75	.014	.021	.0001	.60	5.04	26.5	62.26	1.60
74	1906 Eleventh street NW	123	78	45	do	3.04	.014	.029	.0001	.60	6.3	26.5	77.83	1.60
75	1115 Union court NW	119	85	34	Some charring, odor somewhat disagreeable	2.95	.004	.012	.0002	.63	5.4	26.5	66.83	1.70
76	2125 L street NW	122	81	41	do	2.66	.010	.017	.0001	.63	5.52	26.5	68.19	1.70
78	1667 Euclid street NW	119	78	41	Some charring, odor like burning rubber	2.85	.013	.025	None.	.63	5.89	26.5	72.89	1.75
79	1872 V street NW	117	74	43	Some charring, odor disagreeable	3.20	.018	.019	.0001	.60	6.66	26.5	82.28	1.3
80	2841 Florida avenue NW	116	64	52	Some charring, odor like burning rubber	3.04	.012	.023	None.	.70	6.21	26.0	77.16	2.0
81	2142 K street NW	113	75	38	Some charring, odor more or less disagreeable	3.25	.003	.028	None.	.75	5.28	25.0	63.57	1.7
82	1219 Twenty-ninth street NW	111	76	35	Some charring, odor somewhat disagreeable	3.04	.016	.031	None.	.60	6.46	26.0	80.09	1.75
83	3267 N street NW	112	72	40	Some charring, odor of burning hair	3.2	.023	.016	None.	.75	6.62	28.0	80.83	1.45
84	3616 P street NW	107	74	33	Some charring, odor somewhat disagreeable	3.1	.017	.025	None.	.50	5.85	26.5	72.27	1.55
85	1511 Thirty-fourth street NW	112	66	46	Some charring, no odor	3.3	.006	.019	.0001	.55	5.68	28.0	72.08	1.3
86	2820 P street NW	112	67	45	Some charring, odor disagreeable	3.04	.004	.007	Trace.	......	5.89	27.0	73.35	1.5
90	1621 Minnesota avenue, Anacostia.	133	96	37	Some charring, odor quite disagreeable	2.95	.020	.036	None.	.50	5.73	24.0	67.34	1.09
345	Garnett School, Tenth and W streets NW.	132	92	40	Very slight charring, odor slight, like burning wood.	2.75	None.	.006	Trace.	.65	......	......	......	1.06
346	Business High School, Ninth street NW.	132	82	50	No charring, no odor	2.57	.003	.030	Trace.	.70	......	......	......	.9
347	Garrison, Twelfth street NW	133	99	34	No charring, odor only slight, like burning wood	2.85	.002	.020	Trace.	.75	......	......	......	.8
348	Fountain, Iowa circle	133	92	41	Very slight charring, odor somewhat disagreeable.	2.85	None.	.222	Trace.	.60	......	......	......	.8
349	Sumner School, Seventeenth and N streets NW.	132	98	34	Some charring, odor somewhat disagreeable	2.66	None.	.018	Trace.	.70	......	......	......	.7

TABLE 8.—*Results of analyses of the waters of the deep wells in the District of Columbia.*

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
36	Third and H streets NE	July 24	Very faint yellowish	None	Very slight opalescence	Small amount; whitish.
36	do	Oct. 10	Yellowish	do	Considerable (50)	Considerable.
L	do	July 10				
Ly	do	July 18	Yellowish	None	Slightly cloudy	Iron oxide in suspension.
133	Eleventh and East Capitol streets NE.	Aug. 15	None on collection	Inky	None on collection, (75) on standing.	Slight.
133	do	Aug. 25				
133	do	Oct. 13	Yellowish brown		Considerable (150)	Considerable; yellowish brown.
L	do	July 10				
Ly	do	July 17	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
134	Twelfth and K streets NE	Aug. 15	None on collection, (3) on standing.	None	None on collection, (14) on standing.	None; iron oxide in suspension.
134	do	Oct. 9	Slight yellowish	do	Slight (25)	Slight, heavy, dark, granular.
134	do	Oct. 13				
L	do	July 21				
Ly	do	July 18	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
136	Seventh street and Maryland avenue NE.	Aug. 15	None on collection, (5) on standing.	None	None on collection, (17) on standing.	Slight on standing.
136	do	Oct. 10	Deep yellowish	do	Considerable (150)	Iron oxide in suspension.
L	do	July 10				
Ly	do	July 18	Yellowish	Odorless	Slightly cloudy	Do.
140	B and Warren streets NE	Aug. 16	None on collection, (6) on standing.	Very slight	Slight on collection	Slight; fine, dark brown.
140	do	Aug. 25				
140	do	Oct. 13	Slight brown		Slight on collection (20)	Considerable.
L	do	July 21				
Ly	do	July 18	Yellowish	Odorless	Slightly cloudy	Iron oxide in suspension.
141	Fifteenth street and Maryland avenue NE.	Aug. 16	Yellowish brown	None	Considerable	Considerable iron oxide in suspension.
141	do	Oct. 9	Considerable yellowish		Considerable (60)	Slight.
141	do	Oct. 16	None on collection (yellowish)		Considerable (40)	Considerable.

L	....do	July 21				
Ly	....do	July 19	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
143	Fairview, NE	Aug. 16	Slight (4)	None	Considerable (45)	Slightly ferruginous.
143	....do	Oct. 9	Apparently none	....do	Slight (5)	Very slight.
143	....do	Oct. 16	....do	....do	Slight (15)	Considerable.
L	....do	July 21				
138	Eighth and I streets SE	Aug. 15	Yellowish brown (10)	None	Great (600)	Iron oxide in suspension.
138	....do	Oct. 13	Yellowish brown	....do	Considerable (60)	Do.
L	....do	July 10				
Ly	....do	July 16	Yellowish	Odorless	Cloudy	Do.
R	....do	aFeb. 11			Clear	
3	New Jersey and Massachusetts avenues NW.	July 16	Very slight yellowish	None	Slight milky	None.
3	....do	Oct. 15	....do	....do	Slight (20)	Considerable; yellowish.
L	....do	July 18				
Ly	....do	July 20	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
R	....do	bAug. 26			Clear	
17	Twelfth and M streets NW	July 19	Very slight yellowish	None	Slight opalescence	Slight yellowish.
17	....do	Oct. 15	Considerable yellow	....do	Considerable (75)	Considerable.
L	....do	July 18				
Ly	....do	July 20	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
18	Seventh and M streets NW	July 19	None	None	Very slight opalescence	None.
18	....do	Aug 22				
18	....do	Oct. 15	Slight milky	None	Slight (20)	Very slight; flocculent.
Ly	....do	July 20	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
21	O street, between Sixth and Seventh streets NW.	July 19	None on collection, yellowish brown	None	Great	Considerable iron oxide.
21	....do	Aug. 27				
21	....do	Oct. 15	Strong yellow	None	Considerable (150)	Considerable.
L	....do	July 18				
Ly	....do	July 20	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
71	Pennsylvania avenue and I street NW.	July 31	....do	None	Considerable; slight on collection.	Considerable iron oxide.
71	....do	Oct. 15	....do	....do	Considerable (75)	Do.
Ly	....do	July 23	Yellowish	Odorless	Cloudy	

a 1889. b 1890.

29643—07——21

TABLE 8.—*Results of analyses of the waters of the deep wells in the District of Columbia*—Continued.

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
53	Seventh and H streets SW	July 26	Colorless when fresh	Slightly disagreeable.	Considerable	
53	do	Oct. 12	Yellowish brown	None	Considerable (50)	Considerable; coarse brown.
L	do	July 21				
Ly	do	July 12	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
105	Sixth and B streets NW	Aug. 8	Very slight yellowish	None	Slight	Considerable; fibers of rotten wood.
105	do	Oct. 12	Apparently none	do	Very slight (3)	Considerable; brown, woody.
L	do	July 21				
Ly	do	July 12	Colorless	Odorless	Clear	
107	Sixth and G streets SW	Aug. 9	None on collection, yellow on standing.	None	None on collection, (11) on standing.	Slight white.
107	do	Oct. 12	Apparently none	do	Slight (5)	Do.
L	do	July 21				
Ly	do	July 12	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
108	Half and T streets SW	Aug. 9	None on collection, yellowish	None	None on collection, (65) on standing.	Slight.
108	do	Aug. 26				
108	do	Oct. 16	Slight yellowish	None	Considerable (15)	Some; coarse reddish brown.
L	do	July 21				
Ly	do	July 16	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
110	Third and D streets SW	Aug. 9	None on collection, slight yellow	None	None on collection, (12) on standing.	None.
110	do	Aug. 25				
110	do	Oct. 12	Apparently none	None	Apparently none	Slight; white and brown.
L	do	July 21				
Ly	do	July 12	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
167	Brightwood Hotel, NW	Aug. 22	Apparently none (3)	None	Slight (18)	Slight; white flocculent.
439	do	Oct. 13	Apparently none		Noticeable (20)	Considerable; light brown, fibrous.
Ly	do	July 25	Yellowish	Odorless	Cloudy	

168	Eighth street, between Upshur and Varnum streets NW.	Aug. 22	Yellowish brown (4)	Slightly inky	Marked (120)	Slight; light brown.
168	....do	Oct. 13	Yellowish	None	Somewhat turbid	
Ly	....do	July 25	....do	Odorless	Cloudy	
182	Stanton avenue, Anacostia S E.	Aug. 24	Pale yellow on collection, brown on standing.	Inky	Slight, then great (900)	Heavy, brown, clayey.
388	....do	Oct. 8	Yellow considerable		Considerable	Slight flocculent.
184	Stanton and Elvan avenues S E.	Aug. 24	Slight yellow, then yellow	Slightly inky	Considerable (160)	Slight; dark brown.
L	Broken on Oct. 8					
Ly		July 27	Yellowish	Odorless	Cloudy	
186	Second street and Virginia avenue SW.	Aug. 24	Apparently none (1)	None	Apparently none (3)	Slight, light, flocculent.
186	....do	Aug. 29				
186	....do	Oct. 12	Apparently none	None	Slight (10)	Slight, brown, flocculent.
L	....do	July 21				
Ly	....do	July 12	Yellowish	Odorless	Cloudy	Iron oxide in suspension.
L	Tenth street and South Carolina avenue SE.	July 10				

TABLE 8.—*Results of analyses of the waters of the deep wells in the Dsitrict of Columbia*—Continued.

No.	Location.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° *C.*		
36	Third and H streets NE	107	78	79	Slight darkening due to iron; no odor	4.0	0.020	0.003	0.0	0.0	0.25	16.5	2.53	2.55
36	do	118	88	30	Odor slightly disagreeable	2.4			.0036	.02				
L	do					1.5	.001	.002	.0	.0				
Ly	do					3.0	.015	.05	.0	Tr.				2.2
133	Eleventh and East Capitol streets NE.	103	91	12		0.6	.008	.019		.0	0			4.05
133	do					5.7				.04				
133	do	70	70	None		1.0			.0029	.02				
L	do					0.8	.004	.002	.0	.0				
Ly	do					4.0	.00	.00	.0	Trace				
134	Twelfth and K streets NE					2.4	.010	.0		.0	0	16.5	0	
134	do	108	84	24	Slight darkening due to iron oxide; no odor, no fuming.	1 4			.0010	.0				
134	do	110	84	26	do				.0018	.0				
Ly	do					3.0	.00	.005	.00	Trace				2.6
136	Seventh street and Maryland avenue NE.					2.7	.010	.0		.0	0	18	0	1.2
136	do	102	68	34		2.4			.0023	.02				
L	do					1.3	.007	.002	.0	.0				
Ly	do					3.0	.01	.025	.00	Trace				2.48
140	B and Warren streets NE					1.9	.034	.0	.0	.0	.5	16.5	5.06	1.2
140	do					2.0				.01				
140	do	116	96	20	No charring, some fuming; odor somewhat disagreeable.	0.5			.0075	.0				
L	do					0.8	.030	.006	.0010	.15				
Ly	do					4.0	.03	.01	.00	Trace				.72
141	Fifteenth street and Maryland avenue NE.	128	119	9		2.4	.002	.002	.0	.0	0	16.5	0	.7

141	do	108	84	24	Some darkening due to iron oxide; no odor	1.9			Trace	.02				
141	do					1.9			.0					
L	do					1.4	.008	.002	.0005	.23				
Ly	do					2.0	.005	.005	.00	Trace				2.48
143	Fairview, NE	82	76	6		2.4	.0	.0	.0	.0	0	15	0	.10
143	do	94	66	28	Some darkening due to iron oxide; no odor	2.4			.0017	.01				
143	do					1.9			Trace					
L	do					1.0	.007	.002	.0010	.25				
138	Eighth and I streets SE	147	98	49	Some darkening, no odor	2.7	.010	.042	.0010	.20	.12	16.5	1.214	1.4
138	do	118	92	26	do	1.7			.0020	.0				
L	do					1.4	.002	.002	.00	.00				
Ly	do					8.0	.00	.020	.00	2.00				.32
R	do	442				98.0		.100	.015	25.0				.48
3	New Jersey and Massachusetts avenues NW.	126	94	32	Some darkening due to iron oxide; no odor	6.0	.028	.006	.0	.0		16		2.3
3	do	116	116	None.	do	1.9			.0	.125				
Ly	do					3.0	.00	.00	.00	Trace				
R	do	131				18.0	Trace.	.060	Trace	5.0				.22
17	Twelfth and M streets NW	132	93	39	Some darkening due to iron oxide; no odor	5.5	.024	.044		0	.73	17	7.48	1.75
17	do	100	98	2	do	2.85			.0011	0				
Ly	do					3.00	.00	.00	.00	Trace				.40
18	Seventh and M streets NW	133	92	41	No charring, no odor	10.0	.010	.004		0	.25	16.5	2.53	1.85
18	do					8.0			.0	0				
18	do	124	90	34	No charring, no odor	9.3			Trace	0				
Ly	do					7.0	.00	.005	.00	Trace				.40
21	O street, between Sixth and Seventh streets NW.	462	287	175	Darkening due to iron oxide; odor somewhat disagreeable.		.02	.0		0	0		0	2.5
21	do					78.7				.05				
21	do	372	280	92	Darkening due to iron oxide; odor somewhat disagreeable.	76			Trace	0				
Ly	do					79	.01	.0	0	Trace				.48
71	Pennsylvania avenue and I street NW.	155	91	54	No charring, some fuming, no odor	8.3	.026	.019	.0004	.20	4.55	17	46.56	.90
71	do	126	126	None.	do	7.6			.0017	.125				
Ly	do					8.0	.00	.00	.00	Trace				.40
53	Seventh and H streets SW	197	105	92	No charring, no odor	18.0	.040	.043	.0005	0	.156	17	1.70	1.9

TABLE 8.—*Results of analyses of the waters of the deep wells in the District of Columbia*—Continued.

No.	Location	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° C.		
53	Seventh and H streets SW	162	130	32	No charring, no odor	17.8			.0066	.05				
L	do					14.8	.035	.018	.0010	.15				
Ly	do					23.0	.030	.00	.00	Trace				
105	Sixth and B streets NW	216	170	56	No charring, odor somewhat disagreeable	39.5	.089	0	0	0	.85	18	8.89	.90
105	do	238	204	34	do	37.5			.0018	.50				
L	do					38.0	.07	.003	.0010	.05				
Ly	do					42.0	.06	.00	.00	Trace				
107	Sixth and G streets SW	112	79	33	Some charring; odor disagreeable	6.4	.081	0		0	.22	16.5	2.22	1.30
107	do	132	116	16	No charring, no odor	6.2			.0031	.025				
L	do					4.3	.040	.002	.0010	.12				
Ly	do					8.0	.05	.020	.00	Trace				
108	Half and T streets SW	168	116	52	Some charring due to iron oxide; odor disagreeable.	6.4	.116	0		.10	.56	16.5	5.66	.60
108	do					6.4				.02				
108	do					5.3			.0008					
L	do					5.0	.078	.026	00	.1				
Ly	do					9.0	.160	.00	.00	2.0				.40
110	Third and D streets SW	115	70	45	Some darkening due to iron oxide; odor disagreeable.	3.1	.170	0	.0001	0	.22	16.5	2.22	1.05
110	do					2.8				.01				
110	do	138	106	32	Some darkening due to iron oxide; odor disagreeable.	2.9			0	.01				
L	do					1.7	.126	.002	.0010	.15				
Ly	do					6.0	.12	.01	.00	Trace				.40
167	Brightwood Hotel NW					3.4	.006	.007	.0005	.08	1.3	16	13.07	1.42
439	do	140	100	40	No charring, no odor	1.8			.0035	.00				
Ly	do					3.0	.005	.00	.00	Trace				.48

168	Eighth street, between Upshur and Varnum streets NW.	......	......	......	......	2.1	.009	.024	.001	.05	0	16	0	1.0
168	.....do	76	52	24	No charring, no odor	2.85	......	......	.0038	0	......	......	......	......
Ly	.....do	......	......	......	......	2.0	0	0	.00	Trace	......	......	......	1.08
182	Stanton avenue, Anacostia. SE.	358	328	30	Some darkening due to iron oxide	3.2	.006	.024	......	.1	.23	16.5	2.32	1.3
388	.....do	74	50	24	......	4.3	......	......	0	.125	......	......	......	......
184	Stanton and Elvan avenues SE.	......	......	......	......	2.3	.046	.006	......	.2	0	16	0	.85
Ly	......	......	......	......	......	3.0	.12	.04	.00	Trace	......	......	......	{ 7.80 3.60
186	Second street and Virginia avenue SW.	......	......	......	......	2.25	.060	.005	0	0	.32	16.5	3.24	1.00
186	.....do	......	......	......	......	2.6	......	......	......	.20	......	......	......	......
186	.....do	120	94	26	Slight darkening due to iron oxide; no odor	2.4	......	......	.0025	0	......	......	......	......
L	.....do	......	......	......	......	2.2	.038	.002	0	.20	......	......	......	......
Ly	.....do	......	......	......	......	6.0	.04	.00	.00	Trace	......	......	......	.40
L	Tenth street and South Carolina avenue SE.	......	......	......	......	1.5	.011	.003	.000	.00	......	......	......	......

TABLE 9.—*Results of analyses of the waters of the shallow wells in the District of Columbia, northeast section.*

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
23	Third and D streets NE	July 20	None	None	None	None.
23	....do	Aug. 25				
23	....do	Oct. 10	None	None	None	Very slight.
L	....do	July 7				
Ly	....do	July 19	Colorless	Odorless	Clear	
24	Fourth and E streets NE	July 20	None	None	None	None.
24	....do	July 24	....do	....do	....do	Do.
24	....do	Oct. 10	....do	....do	....do	Considerable, fine brown.
L	....do	July 7				
Ly	....do	July 17	Colorless	Odorless	Clear	
R	....do	[a]July 29			....do	
26	Second and G streets NE	July 20	None	None	None	None.
26	....do	Aug. 25				
26	....do	Oct. 10	None	None	None	Slight.
L	....do	July 7				
Ly	....do	July 19	Colorless	Odorless	Clear	
28	Sixth and C streets (Maryland avenue) NE.	July 20	None	None	None	None.
28	....do	Oct. 10	....do	....do	....do	Slight.
L	....do	July 7				
Ly	....do	July 17	Colorless	Odorless	Clear	
38	E street, between Eighth and Ninth, NE	July 24	None	None	None	None.
38	....do	Oct. 10	....do	....do	....do	Slight, fine fibrous.
L	....do	July 10				
Ly	....do	July 18	Colorless	Odorless	Clear	
R	....do	[b]Dec. 31			Cloudy	
40	Eighth and A streets NE	July 24	None	None	None	None.
40	....do	Oct. 11	....do	....do	....do	Slight, fibrous.
L	....do	July 21				

Ly	....do	July 17	Colorless	Odorless	Clear	
R	....do	[b]Sept. 18			Turbid	
109	North Capitol, between B and C, NE	Aug. 9	None	None	None	None.
109	....do	Aug. 25				
109	....do	Sept. 5				
109	....do	Oct. 5	None	None	None	Very slight, fibrous.
L	....do	July 7				
Ly	....do	July 19	Colorless	Odorless	Clear	
R	....do	[c]Apr. 1			....do	
129	Keating street, between Lincoln avenue and First street, NE.	Aug. 14	None	Disagreeable	None	None.
129	....do	Oct. 9	....do	None	....do	Very slight.
Ly	....do	July 23	Colorless	Odorless	Clear	
135	Eleventh and F streets NE	Aug. 15	Very slight (3)	None	Very slight (1)	None.
135	....do	Aug. 25				
135	....do	Oct. 10	None	None	None	Very slight.
L	....do	July 10				
Ly	....do	July 18	Colorless	Odorless	Clear	
217	Benning crossroads NE	Aug 30	Apparently none (1)	None	Apparently none (0)	Very slight or none.
217	....do	Oct. 12	Apparently none		Apparently none	Slight brown, flocculent.
Ly	....do	July 26	Colorless	Odorless	Clear	
218	Benning School NE	Aug. 30	Yellow, slight increase on standing (4).	Slight inky	Considerable (60)	Considerable, brown.
218	....do	Oct. 12	Considerable brown		Considerable (40)	Slight brown, granular.
224	Quincy street, between Twelfth and Thirteenth (old Philadelphia street), NE.	Aug. 31	Apparently none (2)	None	Apparently none (1)	Very slight.
224	....do	Oct. 9	Apparently none		Very slight (2?)	Very slight, flocculent.
Ly	....do	July 26	Colorless	Odorless	Clear	
225	South Dakota avenue and Vista street NE.	Aug. 31	Blue milky (4)	Strong, disagreeable, suggestion of sewage.	Considerable (25)	Slight, light brown.
225	....do	Oct. 9	Milky		Considerable (30?)	Very slight, flocculent.

[a] 1889. [b] 1887. [c] 1890.

TABLE 9.—*Results of analyses of the waters o the shallow wells in the District of Columbia, northeast section*—Continued.

No.	Location.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° C.		
23	Third and D streets NE	267	161	106	Slight charring, some fumes	50.5	0.004	0.004	0.0015	20.8	6.63	17.0	68.00	0.75
23	do					50.5				25.0				
23	do	298	214	84	No charring, some fumes and odor of hydrochloric acid.	48.5			.0054	20.0				
L	do					48.0	.002	.010	.0003	18.0				
Ly	do					48.0	.005	.010	.000	25.0				.40
24	Fourth and E streets NE	249	182	67	Some charring, no odor	46.5	.006	.002	.0015	17.9	5.81	18.0	60.78	.95
24	do	297	118	179	Slight charring, odor somewhat disagreeable.	46.0	.006	.003	.0015	20.0	5.36			1.05
24	do	252	134	118	Some charring, some fumes, odor of hydrochloric acid.	45.1			.0018	15.6				
L	do					44.0	.009	.011	.0033	16.1				
Ly	do					48.0	.02	.02	.00	20.0				.60
R	do	300				92.0	.008	.092	.000	15.0				.50
26	Second and G streets NE	354	211	143	Slight charring, no odor	63.0	.008	.002	.001	14.7	5.6	16.5	56.78	.75
26	do					61.5				15.0				
26	do	328	176	152	Slight charring, odor somewhat disagreeable.	57.0			.0018	20.0				
L	do					60.0	.008	.006	.0	12.0				
Ly	do					64.0	.00	.01	.00	20.0				.64
28	Sixth and C streets (Maryland avenue) NE.	325	180	145	No charring, some fuming, no odor	80.0	.008	0	.0015	17.9	6.38	17.0	65.43	.95
28	do	360	226	124	No charring, some fumes, odor of hydrochloric acid.	91.8			.0044	25.0				
L	do					82.0	.002	.003	.0011	16.0				
Ly	do					84.0	.00	.01	.00	18.0				.60
38	E street, between Eighth and Ninth, NE	292	268	24	No charring, no odor	54.0	.008	.011	.0015	26.2	6.93	17.0	71.07	2.3
38	do	340	198	142	No charring, sharp penetrating odor.	53.5			.0029	30.0				

L	....do					48.0	.004	.015	.0030	30.0				
Ly	....do					52.0	.005	.005	.00	25.0				.72
R	....do	300				51.0	.004	.060	.015	15.0				.66
40	Eighth and A streets NE	217	132	85	No charring, some fumes, odor of hydrochloric acid.	39.0	0	0	.0003	14.0	6.21	17.0	63.69	1.10
40	....do	232	138	94	....do	36.5			.0026	9.4				
L	....do					39.0	.011	.021	.0040	6.25				
Ly	....do					40.0	.02	.03	.00	15.0				.40
R	....do	174				23.5	.148	.124	.018	5.0				.88
109	North Capitol, between B and C, NE	177	116	61	No charring, no odor	41.5	.013	.010	.0004		5.86	17.0	60.10	.40
109	....do					42.0				10.0				
109	....do					42.0				10.0				
109	....do	252	142	110	No charring, some fuming, odor of hydrochloric acid.	40.0			.0005	7.5				
L	....do					42.0	.006	.013	.0009	7.0				
Ly	....do					45.0	.01	.01	.00	Trace.				.48
R	....do	360				74.0	.200	.152	Trace.	25.0				.70
129	Keating street, between Lincoln avenue and First street, NE	320	220	100	No charring, odor slightly disagreeable.	37.0	.013	.038	.0003	29.4	8.6	16.0	87.04	.10
129	....do	336	174	162	Some charring and fumes, odor of hydrochloric acid and disagreeable.	34.5			.0054	18.7				
Ly	....do					34.0	.00	.00	.00	23.0				.40
135	Eleventh and F streets NE	290	164	126	No charring, no odor	52.5	.014	.011	.0010	12.4	9.4	17.0	96.41	.70
135	....do				No charring, some fuming, no odor	43.0				18.75				
135	....do	228	126	102		42.6			.0013	15.6				
L	....do					37.0	.014	.025	.0008	16.0				
Ly	....do					42.0	.005	.01	.00	20.0				.40
217	Benning crossroads NE						.042	0			1.34	17.0	1.37	3.2
217	....do	396	242	154	Slight charring, some fuming, no odor.	143.3			.0052	12.5				
Ly	....do					133.0	.02	.03	.00	Trace.				.6
218	Benning School NE	98	74	24	No charring, odor nauseous, disagreeable, like stagnant water.	1.6	.028	.017	Trace.	Trace.	1.65	16.0	1.66	1.05
218	....do	88	60	28	No charring, odor somewhat disagreeable.	1.4			.0034	.03				
224	Quincy street, between Twelfth and Thirteenth (old Philadelphia street), NE.					3.2	.004	.001	0	.88	7.11	15.0	7.01	.75

TABLE 9.—*Results of analyses of the waters of shallow wells in the District of Columbia, northeast section*—Continued.

No.	Location.	Total solids.			Conduct on ignition	Chlorine.	Ammonia.		Nitrites.	N·· c	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° *C.*		
224	Quincy street, between Twelfth and Thirteenth (old Philadelphia street), NE.	32	6	26	Some charring, some fuming, odor disagreeable.	4.3	......	......	.0017	6.24	......	......	......	......
Ly	.....do........	......	......	......	....	7.0	.00	.00	.00	Trace.	......	......	......	.4
225	South Dakota avenue and Vista street NE.	144	112	32	Considerable charring, odor quite disagreeable.	6.9	.274	.084	.0040	.08	0	15.0	0	3.65
225	.....do........	92	78	14	.....do........	6.3	......	......	.0082	.03	......	......	......	......

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwest section.*

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
57	Thirty-fourth street and Volta place NW.	July 27	None	None	None	None.
Ly	....do	July 24	Colorless	Odorless	Clear	
58	Thirty-fourth street and Wisconsin avenue NW.	July 27	None	None	None	None.
58	....do	Oct. 4	Apparently none		Apparently none	Slight flocculent.
L	....do	July 18				
Ly	....do	July 24	Colorless	Odorless	Clear	
67	Thirty-fifth and Reservoir streets NW	July 31	Slightly yellowish	None		None.
67	....do	Aug. 23				
67	....do	Aug. 28				
67	....do	Sept. 11				
67	....do	Oct. 4	Apparently none		Apparently none	Very slight, flocculent.
Ly	....do	July 24	Colorless	Odorless	Clear	
72	Third and L streets NW	Aug. 1	Clear, turbid on standing	None	Whitish, turbid	
72	....do	Oct. 3	Apparently none		Very slight, about (2)	Very slight, flocculent.
L	....do	July 7				
Ly	....do	July 19	Colorless	Odorless	Cloudy	
R	....do	[a] Aug. 12			Clear	
77	Sixteenth and Corcoran streets NW	Aug. 2	Colorless	None	None	None.
77	....do	Aug. 23				
77	....do	Oct. 5	Apparently none		Apparently none	Very slightly, flocculent.
L	....do	July 7				
Ly	....do	July 23	Colorless	Odorless	Clear	
R	....do	[a] July 15			....do	
111	New Jersey avenue and Pierce street NW.	Aug. 9	None		None orig. (13) on standing.	None.
111	....do	Aug. 23				

a 1890.

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwest section*—Continued.

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
111	New Jersey avenue and Pierce street NW.	Oct. 3	Apparently none		Slight about (2)	Slight fibrous.
L	....do	July 7				
Ly	....do	July 19				
R	....do	[b] Dec. 4			Milky	
127	Twelfth street and Florida avenue NW	Aug. 14	Clear	None	None	None.
L	....do	July 7				
Ly	....do	July 23	Colorless	Odorless	Clear	
R	....do	[c] Oct. 7			....do	
128	Eighth street and Barry place NW	Aug. 14	None	Slightly woody	None	None.
128	....do	Oct. 6				
L	....do	July 27	None			
Ly	....do	July 25	Colorless	Odorless	Clear	
130	North Capitol and Randolph streets NW.	Aug. 14	None	None	None	None
130	....do	Oct. 6				
L	....do	July 7				
Ly	....do	July 23	Colorless	Odorless	Clear	
131	New Jersey avenue and Morgan street NW.	Aug 14		None		None.
131	....do	Aug. 23				
131	....do	Aug. 27				
131	....do	Sept. 5				
131	....do	Oct. 3	Apparently none		Apparently none (0)	Very slight, dark.
L	....do	July 7				
Ly	....do	July 19	Colorless	Odorless	Clear	
169	Newton street east of Brightwood avenue NW.	Aug. 22	Apparenly none (1)	Woody, slight	Apparently none	Very slight, white floating particles.
169	....do	Oct. 10	....do		....do	Slight, fine fibrous.
L	....do	July 7				

Ly	....do	July 25	Colorless	Odorless	Clear	
170	Sixth street north of Fairmont street NW.	Aug. 22	Apparently none (1)	None	Apparently none (1)	Slight, white, fibrous floating.
170	....do	Oct. 6	....do		Apparently none	Slight, light flocculent.
170	....do	Oct. 16				
L	....do	July 7	Colorless			
Ly	....do	July 25	....do	Odorless	Clear	
175	Thirty-third street and Wisconsin avenue NW.	Aug. 23	Marked yellowish (6)	None	Marked (75)	None.
175	....do	Oct. 4	Apparently none		Apparently none	Very slight, flocculent.
201	Spring at Zoological Park near office	Aug 28	Apparently none (2)	None	Apparently none (2)	Fine, black.
202	Pump, Zoological Park	Aug. 28	Light brown (6)	....do	Slight (18)	Considerable coarse brown.
203	Spring, Zoological Park, near refreshment stand.	Aug. 28	Apparently none (3)	....do	Apparently none (1)	Slight black.
204	Massachusetts avenue, near Wisconsin avenue NW.	Aug. 28	Apparently none (1)	Slight woody	Apparently none (0)	None or very little.
204	....do	Sept. 11				
204	....do	Oct. 15	Apparently none		Apparently none	Very slight black granular.
L	....do	July 18				
Ly	....do	July 24	Colorless	Odorless	Clear	
226	Brightwood avenue, near District line NW.	Aug. 31	Gray (3)	Slight earthy	Considerable (35)	Slight, light brown.
226	....do	Oct. 13	Apparently none		Slight (10?)	Very slight flocculent.
Ly	....do	July 25	Colorless	Odorless	Clear	
235	Hurst and Elliott streets NW	Sept. 4	Apparently none	None	Apparently none	Slight coarse, yellowish brown.
235	....do	Oct. 15	....do	Considerable oily	....do	Considerable fibrous.
L	....do	Aug. 3				
267	Seventh street and Center Market NW.	Sept. 11	Slight on collection, iron oxide.	Slightly inky	Slight on collection, iron	Considerable iron deposit.
5	Sixth street, between F and G streets NW.	July 16	None		None, very clear	None.
5	....do	Aug. 22				
5	....do	Sept. 5				
5	....do	Oct. 5	Apparently none		Apparently none	None.
L	....do	July 7				
Ly	....do	July 20	Colorless	Odorless	Clear	
R	....do	[a]Oct. 3			....do	

[b] 1888. [c] 1891. [a] 1887.

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwest section*—Continued.

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
6	Ninth and H streets NW	July 16	None		None, very clear	None.
6	do	Aug. 22				
6	do	Aug. 27				
6	do	Oct. 5	Apparently none		Apparently none	Very slight.
L	do	July 7				
Ly	do	July 24	Colorless	Odorless	Clear	
8	Tenth and N streets NW	July 17	None	None	Very slight	Slight yellowish.
8	do	Oct. 3	Apparently none		Very slight (3)	Slight granular and fibrous.
8	do	Oct. 16	do		Slight (5?)	Slight light brown.
L	do	July 7				
Ly	do	July 20	Colorless	Odorless	Clear	
9	Tenth and K streets NW	July 17	None	None	Very slight trace	Traces, white.
9	do	Oct. 3	Apparently none		Very slight (1)	None.
L	do	July 5				
Ly	do	July 20	Colorless	Odorless	Clear	
11	Seventeenth and K streets NW	July 17	do	None	None	Reddish brown, small, probably from pump.
11	do	Aug. 23				
11	do	Aug. 27				
11	do	Sept. 5				
11	do	Oct. 5	Apparently none		Apparently none	Very slight.
L	do	June 26				
Ly	do	July 23	Colorless	Odorless	Clear	
13	Third and Indiana avenue NW	July 18	None		None	None.
13	do	Aug. 23				
13	do	Aug. 27				
13	do	Sept. 5				
13	do	Oct. 5	Apparently none		Apparently none	Slight flocculent brown.
L	do	July 7				

Ly	....do	July 12	Colorless	Odorless	Clear	
R	....do	a Oct. 7			....do	
14	New York avenue, between Fourth and Fifth streets NW.	July 18	None		None	
14	....do	Aug. 22				
14	....do	Aug. 27				
14	....do	Oct. 3	Apparently none		Very slight, about (1)	Slight flocculent.
14	....do	Oct. 16	None		None	Very slight, dark, flocculent.
L	....do	July 7				
Ly	....do	July 19	Colorless	Odorless	Clear	
15	Massachusetts avenue, between Sixth and Seventh streets NW.	July 18	None		None	
15	....do	Aug. 22				
15	....do	Aug. 27				
15	....do	Oct. 5	Apparently none		Apparently none	Very slight, white fibrous.
L	....do	July 7				
Ly	....do	July 20	Colorless	Odorless	Clear	
44	Wisconsin avenue and Q street NW	July 25	None	None	None	None.
44	....do	Oct. 4	Apparently none		Apparently none	Very slight, flocculent.
L	....do	July 5	None		None	
Ly	....do	July 24	Colorless	Odorless	Clear	
45	Thirty-second and Q streets NW. (opposite 1614 Thirty-second street).	July 25	None	None	None	None.
45	....do	Aug. 23		Very slight		
45	....do	Sept. 20	Apparently none (1)		Apparently none (0)	None.
45	....do	Oct. 4	Apparently none		Apparently none	Very slight, flocculent.
L	....do	July 5				
Ly	....do	July 23	Colorless	Odorless	Clear	
46	Wisconsin avenue and P street NW. (facing 1522 Wisconsin avenue).	July 25	Very slight yellowish	None	None	None.
46	....do	Sept. 11				
46	....do	Oct. 4	Apparently none		Apparently none	Slight, flocculent.
L	....do	July 5				

a 1888.

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwest section*—Continued.

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
48	Twenty-eighth and O streets NW	July 25	Very slight yellowish	Earthy and slightly disagreeable.	Very slight	None.
48	.....do	Aug. 27				
48	.....do	Oct. 4	Apparently none		Apparently none	
L	.....do	July 5				
Ly	.....do	July 23	Colorless	Odorless	Cloudy	

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwest section*—Continued.

No.	Location.	Total residue.	Mineral matter.	Volatile matter.	Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
							Free.	Albuminoid.						
												° C.		
57	Thirty-fourth street and Volta place NW.	401	313	88	No charring, no odor	70.5	0.008	0.008	0.0002	38.4	8.94	16.0	89.93	0.995
Ly	do					76.00	.00	.00	.00	30.00				.32
58	Thirty-fourth street and Wisconsin avenue NW.	363	279	84	Slight charring, no odor	67.5	.010	.057	Trace.	38.4	6.89	14.5	68.26	1.03
58	do	600	330	270	No charring, some fuming, odor of hydrochloric acid strong.	62.5			.0001	25.0				
L	do					66.0	.018	.027	.0005	.5				
Ly	do					70.0	.00	.00	.00	35.00				.40
67	Thirty-fifth and Reservior streets NW.	248	183	65	Very slight charring, no odor	57.5	.018	.010	.00045	20.0	5.28	15.5	52.58	1.75
67	do					61.0				20.0				
67	do									20.0				
67	do									15.0				
67	do	346	184	162	No charring, no odor	68.0			.005	20.0				
Ly	do					60.00	.00	.00	.00	27.5				.36
72	Third and L streets NW	356	205	151	Some darkening, probably due to iron, odor somewhat disagreeable.	61.5	.020	.0	.0013	17.00	2.88	16.0	28.97	.7
72	do	354	216	138	No charring, some fuming, odor hydrochloric acid distinct.	60.0			.0022	12.5				
L	do					61.0	.020	.020	.0025	10.0				
Ly	do					63.00	.005	.02	.00	15.00				.40
R	do	411				63.6	Trace.	.100	.000	15.0				.10
77	Sixteenth and Corcoran streets NW	160	84	76	No charring, some fuming, no odor	21.5	.024	.005	.0004	11.9	6.34	19.0	67.66	.68
77	do					26.0				10.0				
77	do	158	102	56	No charring, no odor	26.0			.0006	17.5				
L	do					21.0	.001	.001	.0001	9.0				
Ly	do					22.0	.00	.015	.00	Trace.				.40
R	do	186				26.0	.032	.072	.000	2.0				.28
111	New Jersey avenue and Pierce street NW.	238	164	74	Slight charring, some odor	46.0	.004	.002	.0003		7.31	16.0	73.97	.55

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwest section*—Continued.

No.	Location.	Total residue.	Mineral matter.	Volatile matter.	Conduct on ignition.	Chlorine.	Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
												° *C.*		
111	New Jersey avenue and Pierce street NW.					46.5				18.5				
111	....do	290	180	110	No charring, no odor	42.5			.0006	15.0				
L	....do					45.0	.002	.006	.0002	15.0				
Ly	....do					49.00	.00	.02	.00	23.00				.56
R	....do	286				54.0	.060	.132	.025	15.0				3.52
127	Twelfth street and Florida avenue NW.	176	154	22	No charring, no odor	12.0	None.	.020	None.	3.0	4.8	17.5	49.53	.3
L	....do					10.0	.002	.002	.0000	2.5				
Ly	....do					11.0	.00	.00	.00	2.0				.6
R	....do	66				0.5	.008	.020	.000	3.0				.22
128	Eighth street and Barry place NW					16.5	.018	.026	.0005	6.0	4.53	18.5	47.68	.1
128	....do	178	92	86	No charring, some fuming, no odor	20.0			.0005	7.5				
L	....do					11.0	.007	.008	.000	4.5				
Ly	....do					15.0	.00	.00	.00	5.0				.40
130	North Capitol and Randolph streets NW.					13.0	.012	.005	.0015	7.0	3.31	16.5	34.51	.1
130	....do	110	54	56	No charring, some fuming, no odor	13.5			.0007	5.0				
L	....do					12.0	.004	.002	.0060	5.5				
Ly	....do					13.00	.00	.00	.00	Trace.				.40
131	New Jersey avenue and Morgan street NW.	386	230	156	No charring, some fuming, odor of hydrochloric acid.	63.0	.014	.005	.0015	25.0	7.43	16.5	75.20	.70
131	....do					64.0				25.0				
131	....do									25.0				
131	....do					65.5								
131	....do	382	256	126	No charring, some odor of hydrochloric acid.	64.5			.0010	25.0				
L	....do					60.0	.001	.002	.0014	18.0				
Ly	....do					63.00	.00	.005	.00	30.0				.28

169	Newton street east of Brightwood avenue NW.					32.5	.010	.040	.0004	20.0	4.95	16.0	49.79	.45
169	....do	270	132	138	Considerable charring, some fuming, some odor.	32.0			.0013	20.0				
L	....do					31.00	.001	.005	.0004	20.0				
Ly	....do					33.00	.00	.00	.00	25.0				.80
170	Sixth street north of Fairmont street NW.					43.0	None.	None.	.0004	12.5	8.08	16.0	81.27	1.2
170	....do	342	150	192	No charring, some fuming, odor somewhat disagreeable.	70.0			.0014	20.0				
170	....do	760	190	70	Slight charring, odor of hydrochloric acid.	44.5			.009					
L	....do					43.0	.003	.001	.002	14.0				
Ly	....do					40.0	.00	.00	.00	15.00				.32
175	Thirty-third street and Wisconsin avenue NW.	138	124	14	No charring, odor only slightly disagreeable.	4.3	.014	.024	.0008	1.25	9.10	16.0	91.55	.95
175	....do	114	64	50	No charring, no odor	4.3			.0006	1.0				
201	Spring at Zoological Park, near office	146	116	30	Slight charring, odor somewhat disagreeable.	5.4	.016	.024	.0002	2.25	8.74	15.0	86.19	1.30
202	Pump, Zoological Park	162	116	46	Considerable charring, odor quite disagreeable.	13.8	.026	.058	.0050	.058	2.6	21.0	28.85	1.3
203	Spring, Zoological Park, near refreshment stand.	114	100	14	Slight charring, no odor	4.1	.010	.024	None.	0.15	7.68	15.0	75.74	1.25
204	Massachusetts avenue, near Wisconsin avenue NW.					22.0	.028	.030	.0030	.4	7.92	14.5	77.49	.85
204	....do					21.0				.375				
204	....do	54	60	None.	Slight charring, odor somewhat disagreeable.	21.3			.0010	.50				
L	....do					23.0	.009	.012	.020	32.5				
Ly	....do					26.0	.02	.00	.02	Trace.				.40
226	Brightwood avenue, near District line NW.	92	62	30	Some charring, odor disagreeable	14.0	.007	.018	.0005	2.5	7.11	17.0	72.92	1.75
226	....do	62	30	32	Slight charring, slight disagreeable odor.	12.7			.0048	2.5				
Ly	....do					12.0	.00	.00	.00	Trace.				.40
235	Hurst and Elliott streets NW	60	46	14	Slight charring, some fuming, odor disagreeable.	7.9	.005	.024	.0030	1.75	3.85	16.0	38.63	1.4
235	....do	98	76	22	Slight charring, odor slightly disagreeable.	9.1			.0114	1.5				
L	....do					6.5	.018	.018	.0375	1.9				

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwes section*—Continued.

No	Location.	Total residue.	Mineral matter.	Volatile matter.	Conduct on ignition.	Chlorine.	Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
												° C.		
267	Seventh street and Center Market NW.	704	226	78	Some darkening, due to iron oxide, no odor.	48.0	.246	.016	.0002	None.	......	17.0	......	1.9
5	Sixth street, between F and G streets N W.	565	380	185	No charring, no odor	73.0	.016	.006	.00075	25.0	......	17.0	......	1.3
5	.....do	......	......	......	......	65.0	......	......	......	26.5	......	......	......	......
5	.....do	......	......	......	......	......	......	......	......	30.0	......	......	......	......
5	.....do	562	384	178	No charring, some fuming, odor of hydrochloric acid.	......	......	......	.0007	20.0	......	......	......	......
L	.....do	......	......	......	......	71.0	.002	.007	.0008	30.0	......	......	......	......
Ly	.....do	......	......	......	......	74.00	.00	.04	.00	35.0	......	......	......	.48
R	.....do	340	......	......	......	58.8	.028	.060	.005	23.0	......	......	......	.40
6	Ninth and H streets NW	277	193	84	Very little charring, odor resinous	52.0	.016	.016	.0005	5.0	......	17.0	......	1.2
6	.....do	......	......	......	......	52.0	......	......	......	8.75	......	......	......	......
6	.....do	......	......	......	......	......	......	......	......	7.5	......	......	......	......
6	.....do	226	162	64	No charing, some fuming, odor slightly disagreeable.	45.5	......	......	.0007	7.5	......	......	......	......
L	.....do	......	......	......	......	51.0	.007	.012	.0002	7.5	......	......	......	......
Ly	.....do	......	......	......	......	55.00	.005	.00	.00	12.0	......	......	......	.36
8	Tenth and N streets NW	......	......	......	......	71.0	.016	.030	.0033	22.3	......	18.4	......	1.6
8	.....do	420	270	150	No charring, some fuming, odor of hydrochloric acid.	66.5	......	......	.0052	......	......	......	......	......
8	.....do	......	......	......	......	67.0	......	......	......	25.0	......	......	......	......
L	.....do	......	......	......	......	67.0	.012	.013	.0030	24.0	......	......	......	......
Ly	.....do	......	......	......	......	78.00	.00	.00	.0002	25.0	......	......	......	.60
9	Tenth and K streets NW	395	208	187	No charring, no odor	54.0	.009	.006	.001	16.7	......	18.0	......	1.5
9	.....do	394	194	200	.....do	52.0	......	......	Trace.	17.5	......	......	......	......
L	.....do	......	......	......	......	......	......	......	......	......	......	......	......	......
Ly	.....do	......	......	......	......	50.00	.00	.00	.00	22.00	......	......	......	.60
11	Seventeenth and K streets NW	200	79	121	Slight charring, odor disagreeable	31.0	.008	0	.0005	6.25	......	19.0	......	.8

11	....do					31.0				12.5				
11	....do									12.5				
11	....do									12.5				
11	....do	182	122	60	No charring, no odor	29.5			.0007	7.5				
L	....do													
Ly	....do					28.00	.01	.00	.00	Trace.				.32
13	Third street and Indiana avenue NW	292	195	97	No charring, odor peculiar and resinous.	58.0	.016	.019	.007	12.5		18.0		.90
13	....do					50.0				11.0				
13	....do									12.5				
13	....do					46.5				12.5				
13	....do	302	200	102	No charring, some fuming, no odor	49.0			.0037	12.5				
L	....do					41.0	.002	.008	.0020	11.0				
Ly	....do					47.00	.005	.01	.004	Trace.				.44
R	....do	392				72.5	.020	.152	.024	15.0				.66
14	New York avenue, between Fourth and Fifth streets NW.	368	248	120		51.5	.014	.004	.0011	22.3		18.5		.95
14	....do					51.0				17.5				
14	....do									20.0				
14	....do	324	236	88	No charring, odor of hydrochloric acid.	45.0			.0009	18.7				
14	....do					45.5			.0008					
L	....do					52.0	.005	.006	.0002	18.0				
Ly	....do					53.0	.02	.04	.00	28.00				.40
15	Massachusetts avenue, between Sixth and Seventh streets NW.	378	148	230	No charring, odor disagreeable	71.0	.008	.004	.00156	15.4				.90
15	....do					72.5				15.0				
15	....do									20.0				
15	....do	380	216	164	No charring, some fuming, odor of hydrochloric acid.	73.0			.0015	15.0				
L	....do					68.0	.002	.002	.0015	15.0				
Ly	....do					74.0	.00	.00	.00	20.0				.40
44	Wisconsin avenue and Q street NW	430	317	113	No charring, odor like burning rubber.	89.0	.006	.011	Trace.	20.0	5.38	16.0	54.12	1.00
44	....do	554	318	236		95.5			.009	10.0				
L	....do					66.0	.018	.026	.0016	15.62				
Ly	....do					90.00	.00	.00	.00	15.0				.36

TABLE 10.—*Results of analyses of the waters of shallow wells in the District of Columbia, northwest section*—Continued.

No.	Location.	Total residue.	Mineral matter.	Volatile matter.	Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
							Free.	Albuminoid.						
45	Thirty-second and Q streets NW. (opposite 1614 Thirty-second street).	359	222	137		45.0	.010	.003	.0015	18.0	6.09	16.0	61.27	2.35
45	do				No charring, some fuming, no odor	43.8	.002	.014	Trace.			15.5		
45	do	280	186	94	No charring, odor of hydrochloric acid.	44.0			Trace.	15.0	4.84			.15
45	do	314	136	178		46.0				18.5				
L	do													
Ly	do					69.00	.00	.00	.00	20.0				.40
46	Wisconsin avenue and P street NW. (facing 1522 Wisconsin avenue).	476	344	132	Slight charring, odor slightly disagreeable.	68.5	.008	.019	.0015	24.0	5.64	16.0	56.74	1.25
46	do									15.0				
46	do	450	244	206	No charring, no odor	71.0			.0009	17.0				
L	do													
48	Twenty-eighth and O streets NW	397	318	79	No charring, no odor	47.0	.008	.007	.005	20.0	7.84	16.0	78.87	1.35
48	do									12.5				
48	do	390	202	188	No charring, some fuming, odor of hydrochloric acid.	46.5			Trace.	15.0				
L	do													
Ly	do					45.0	.01	.02	.00	15.00				

TABLE 11.—*Results of analyses of the waters of shallow wells in the District of Columbia, southeast section.*

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
30	Fourth street and South Carolina avenue SE.	July 23	None	Earthy	None	None.
30	....do	Aug. 17				
30	....do	Oct. 9	Apparently none	None	Apparently none	Do.
L	....do	July 10				
Ly	....do	July 13	Colorless	Odorless	Clear	
R	....do	a Aug. 16			Cloudy	
32	Fifth and G streets SE	July 23	None	Earthy	None	Do.
32	....do	Aug. 17				
32	....do	Oct. 9	Apparently none	None	Apparently none	Do.
L	....do	July 10				
Ly	....do	July 13	Colorless	Odorless	Clear	
34	Fourth Street and Seward square SE.	July 23	None	None	None	Do.
34	....do	Oct. 9	....do	....do	....do	Slight; flocculent.
L	....do	July 10				
Ly	....do	July 16	Colorless	Odorless	Clear	
35	Third and C streets SE	July 23	None	Slightly disagreeable; woody.	None	None.
35	....do	Aug. 24				
35	....do	Oct. 9	None	None	None	Do.
L	....do	July 10				
Ly	....do	July 13	Colorless	Odorless	Clear	
R	....do	a July 29			....do	
91	Harrison and Seventeenth streets SE.	Aug. 6	None	None	Trace	None.
91	....do	Aug. 17				
91	....do	Oct. 8	None	None	None	Slight; white, flocculent.
91	....do	Oct. 15				
L	....do	July 27	Colorless	Odorless	Clear	
Ly	....do	July 26				

a 1890.

TABLE 11.—*Results of analyses of the waters of shallow wells in the District of Columbia, southeast section*—Continued.

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
92	Seventh and B streets SE	Aug. 6	None	None	None	None.
92	do	Oct. 11	do	do	do	Do.
L	do	July 10				
Ly	do	July 13	Colorless	Odorless	Clear	
101	Third street and Pennsylvania avenue SE.	Aug. 8	None	Slightly woody	None	Do.
101	do	Oct. 23	do	None	do	Do.
L	do	July 10				
Ly	do	July 13	Colorless	Odorless	Clear	
R	do	[a]May 20			do	
102	Seventh, between B and C streets SE	Aug. 8	None	None	None	Do.
102	do	Oct. 11	do	do	do	Slight; light brown, flocculent.
L	do	July 10				
Ly	do	July 16	Colorless	Odorless	Clear	
R	do	[b]Apr. 2			do	
103	Eighth and D streets SE [c]	Aug. 8	Very slight; yellowish	Woody	None	Very slight; trash.
L	do	July 10				
Ly	do	July 16	Colorless	Odorless	Clear	
116	Jefferson between Monroe and Fillmore street, Anacostia.	Aug. 10	Slight (2)	None	Slight (1)	None.
116	do	Aug. 24				
116	do	Oct. 8	None	None	None	Considerable; white, flocculent.
L	do	July 26				
Ly	do	July 27	Colorless	Odorless	Clear	
117	Fillmore and Jackson streets SE., Anacostia.	Aug. 10	Very slight (2)	None	None	None.
117	do	Aug. 24				
117	do	Aug. 29				
117	do	Sept. 19				

117	....do	Oct. 8	None	None	None	Very slight.
L	....do	July 26				
Ly	....do	July 27	Colorless	Odorless	Clear	
139	L, between Thirteenth and Fourteenth streets SE.	Aug. 16	Yellowish (10)	Earthy	Considerable (40)	Considerable; brown, flocculent.
139	....do	Aug. 25				
139	....do	Sept. 19				
139	....do	Oct. 13	None	None	None	Slightly flocculent.
Ly	....do	July 17	Yellowish	Odorless	Cloudy	Organic matter in suspension.
145	Eleventh street and South Carolina avenue SE.	Aug. 17	None	None	None	Slight; flocculent.
145	....do	Oct. 11	Considerable; yellowish brown.	....do	Slight (3)	Slight; light brown.
Ly	....do	July 16	Colorless	Odorless	Clear	
146	I, between Eleventh and Twelfth streets SE.	Aug. 17	None	None	None	None.
146	....do	Oct. 13	....do	....do	....do	Do.
L	....do	July 10				
Ly	....do	July 17	Colorless	Odorless	Clear	
183	Hamilton road, SE., Anacostia	Aug. 24	Very slight (4)	None	None (0)	Slight; dark brown.
183	....do	Oct. 8	None	....do	Very slight	Considerable; fibrous.
Ly	....do	July 27	Colorless	Odorless	Clear	
185	Stanton and Pomeroy (Morris) streets SE., Anacostia	Aug. 24	None	None	Very slight (1)	A few filaments.
185	....do	Aug. 29				
185	....do	Sept. 19				
185	....do	....do				
185	....do	Oct. 8	None	None	None	None.
L	....do	July 26				
Ly	....do	July 27	Colorless	Odorless	Clear	
208	Stanton School, Good Hope, SE	Aug. 29	Slight (7)	Slightly woody	Slight (25)	Considerable.
208	....do	Sept. 11				
208	....do	Oct. 8	None	None	Very slight	Slight.
209	Twentieth and Joliet streets SE	Aug. 29	Very slight (2)	Slightly woody	Very slight (1)	None.
300	....do	Sept. 19	....do	Slightly earthy	....do	Do.
300	....do	Oct. 8	Very slight	None	Very slight	Do.

a 1889.

c Out of order on Oct. 11, 1906.

TABLE 11.—*Results of analyses of the waters of shallow wells in the District of Columbia, southeast section*—Continued.

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
385	T street hill, Anacostia, SE. (closed on first survey).	Oct. 8	Considerable; milky	None	Considerable	Considerable.
R	....do	[a]Dec. 9			Very turbid	
422	Ninth and E streets SE	Oct. 11	None	None	None	Slight; fibrous.
Ly	....do	July 16	Colorless	Odorless	Clear	
		Aug. 29				
		Oct. 13				
L	Thirteenth, between D and E streets SE	July 10				

[a] 1888.

TABLE 11.—*Results of analyses of the waters of shallow wells in the District of Columbia, southeast section.*

No.	Location.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												°C.		
30	Fourth street and South Carolina avenue SE.	175	78	97	Gives off some fumes	39.0	0.010	0.024	0.0010	5.0	5.6	18.0	58.57	0.8
30	....do					38.0			.0025	6.25				
30	....do	226	152	74		40.5			.0067	6.25				
L	....do					42.0	.007	.004	.0015	6.5				
Ly	....do					40.0	.00	.00	.00	Trace.				.44
R	....do	220				44.0	2.000+	.281+	Trace.	15.0				.30
32	Fifth and G streets SE	418	136	282	Slight charring, abundant whitish fumes; odor disagreeable.	57.0	.016	.006	.0010	26.8	2.0	17.0	20.51	.95
32	....do					56.0			.00	25.0				
32	....do	460	290	170	Some charring, some fuming; odor slightly disagreeable.	55.5			.0010	25.0				
L	....do					53.0	.005	.002	.0002	[illegible]				
Ly	....do					56.0	.005	.00	.00	30.0				.40
34	Fourth street and Seward square SE	259	79	180	Some charring, gives off white fumes; odor of burning wood.	47.5	.038	.000	.0010	13.5	8.25	17.0	84.61	.70
34	....do	276	160	116	Some charring; odor of hydrochloric acid; disagreeable.	43.5			.0010	19.0				
L	....do					45.0	.013	.009	.0010	15.0				
Ly	....do					48.0	.00	.00	.00	18.0				.40
35	Third and C streets SE	256	237	19	No charring; no odor	60.0	.011	.012	.0045	12.5	4.19	19.0	44.71	1.1
35	....do					58.5				17.5				
35	....do	314	186	128	Some charring; odor disagreeable	58.0			.0017	15.0				
L	....do					58.0	.007	.046	.0003	15.0				
Ly	....do					58.0	.00	.00	.0020	18.0				1.12
R	....do	443				109.0	.020	.216	.005	28.0				2.70
91	Harrison and Seventeenth streets SE	206	100	106	Some charring; odor disagreeable	18.5	.015	.004	.0015	12.5	4.10	17.5	42.48	.40
91	....do					17.0				9.0				

TABLE 11.—*Results of analyses of the waters of shallow wells in the District of Columbia, southeast section*—Continued.

No	Location.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° C.		
91	Harrison and Seventeenth streets SE.	156	54	102	No charring, some fuming; odor disagreeable.	16.5	....	....	.0041	7.5	....	....	....	....
91	.....do	....	....	....	....	16.6	....	....	.0022	....	....	....	....	....
L	.....do	....	....	....	....	6.6	.001	.001	.0030	10.0	....	....	....	....
Ly	.....do	....	....	....	....	14.0	.00	.00	.00	10.0	....	....	....	.40
92	Seventh and B streets SE	175	134	41	Some charring; odor of burning wood.	41.0	.004	.000	.0008	25.0	3.9	17.0	40.00	.35
92	.....do	270	156	114	Slight charring, slightly disagreeable odor, some fuming.	41.3	....	....	.0058	15.6	....	....	....	....
L	.....do	....	....	....	....	40.0	.018	.029	.0010	20.0	....	....	....	....
Ly	.....do	....	....	....	....	38.0	.005	.00	.00	22.0	....	....	....	....
101	Third street and Pennsylvania avenue SE.	....	....	....	....	66.5	.016	0.010	.0010	17.5	3.86	16.5	39.09	.65
101	.....do	296	192	104	No charring; slight odor of hydrochloric acid.	68.5	....	....	.0578	12.5	....	....	....	....
L	.....do	....	....	....	....	66.0	.004	.001	.0027	15.0	....	....	....	....
Ly	.....do	....	....	....	....	70.0	.00	.00	.002	20.0	....	....	....	.40
R	.....do	246	....	....	....	74.0	.020	.121	.000	18.0	....	....	....	.90
102	Seventh, between B and C streets SE	206	90	116	No charring, some fuming; odor of hydrochloric acid.	35.0	.011	.000	.00	18.0	8.17	15.5	81.37	.40
102	.....do	290	180	110	No charring, some fuming; odor slightly disagreeable.	86.5	....	....	.0025	12.5	....	....	....	....
L	.....do	....	....	....	....	33.0	.001	.002	.0003	14.0	....	....	....	....
Ly	.....do	....	....	....	....	37.0	.01	.00	.00	15.0	....	....	....	.40
R	.....do	384	....	....	....	74.5	.032	.324	.015	15.0	....	....	....	1.14
103	Eighth and D streets SE	....	....	....	....	56.0	.018	.015	.0008	20.5	3.86	22.0	43.66	.65
L	.....do	....	....	....	....	56.0	.001	.051	.0030	18.0	....	....	....	....
Ly	.....do	....	....	....	....	62.0	.02	.005	.00	20.0	....	....	....	.52
116	Jefferson between Monroe and Fillmore streets, Anacostia.	274	160	114	No charring, some fuming; odor of hydrochloric acid.	45.5	.006	.000	.0040	20.0	2.46	17.0	26.25	1.2

116	....do					46.0				12.5				
116	....do	286	162	124	Some charring, considerable fuming; odor slightly disagreeable.	43.5			.0033	12.5				
L	....do					3.3	.005	.005	.003	27.5				
Ly	....do					46.0	.00	.00	.00	15.0				.48
117	Fillmore and Jackson streets SE., Anacostia.	282	194	88	No charring, some fuming; odor of hydrochloric acid.	40.0	.014	.000	.0006	19.0	3.61	15.0	25.60	1.05
117	....do					37.0				20.0				
117	....do					39.5								
117	....do					38.5				17.5				
117	....do	226	112	114	Slight charring, some fuming; odor of hydrochloric acid.	32.5			.010	8.9				
L	....do					81.0	.001	.005	.0030	25.0				
Ly	....do					43.0	.00	.00	.00	30.0				.68
139	L, between Thirteenth and Fourteenth streets SE.	134	50	84	Some charring, some fuming, odor disagreeable.	9.4	.022	.073	.0010	6.4	7.68	20.0	82.37	3.75
139	....do					17.9				10.0				
139	....do					19.0				5.0				
139	....do	122	78	44	Slight charring, some fuming, some odor.	19.7			.0023	5.0				
Ly	....do					22.0	.04	.02	.064	Trace.				4.40
145	Eleventh street and South Carolina avenue SE.	54	54	0	Some charring, no odor	19.0	.022	.035	.0071	1.0	3.69	21.0	45.5	1.05
145	....do	112	78	33	Some darkening, due to iron oxide; no odor.	12.5			.0028	.08				
Ly	....do					22.0	.00	.00	.00	Trace.				.60
146	I, between Eleventh and Twelfth streets SE.					38.5	.012	.00	.00	17.5	2.56	16.5	25.91	.65
146	....do	252	152	100	Slight charring, some fuming; no odor.	41.7			.0016	15.0				
L	....do					32.0	.006	.002	.0008	12.5				
Ly	....do					38.0	.00	.00	.00	15.0				.40
183	Hamilton road SE., Anacostia	114	96	18	Slight charring; odor somewhat disagreeable.	7.0	.043	.003	.0040	.90	7.38	16.0	74.24	.85
183	....do	38	6	32	Some charring, no odor	6.2			.0134	.75				
Ly	....do					7.0	.00	.00	.00	Trace.				.40
185	Stanton and Pomeroy (Morris) streets SE., Anacostia.					76.5	.00	.023	.0015	17.5	5.24	16.5	53.03	.95
185	....do					51.5								

TABLE 11.—*Results of analyses of the waters of shallow wells in the District of Columbia, southeast section*—Continued.

No.	Location.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
												° *C.*		
185	Stanton and Pomeroy (Morris) streets SE., Anacostia.					102.5								
185	....do					68.5				31.5				
185	....do	372	224	148	Some charring, some fuming; odor pungent and acrid.	85.5			.0039	15.6				
L	....do					13.5	.015	.02	.0020	16.25				
Ly	....do					95.0	.00	.01	.00	20.0				.48
208	Stanton School, Good Hope, SE	332	262	70	No charring; odor of hydrochloric acid, and disagreeable.	22.0	.058	.042	.0030	.40	3.57	16.0	35.81	2.2
208	....do					21.0				.375				
208	....do	366	230	136	No charring; odor of hydrochloric acid.	16.0			.0111	.465				
209	Twentieth and Joliet streets SE	82	56	26	No charring; odor somewhat disagreeable.	3.9	.027	.020	.0020	.75	9.18	15.0	90.63	1.15
300	....do					5.3	.014	.022	.0010	.70	8.13	15.5		.20
300	....do	36	36	0	Slight charring, slight odor	3.3			.0032	1.0				
385	T street hill, Anacostia, SE (closed on first survey).	42	38	4	No charring, no odor	8.6			.0179	.40				
R	....do	202				37.5	.360	.208	.000	0.0				5.10
422	Ninth and E streets SE	282	190	92	No charring, some fuming, some odor of hydrochloric acid, and disagreeable.	67.5	.016	.00	.0021	15.6				
Ly	....do					75.0	.00	.00	.00	15.0				.32
L	Thirteenth, between D and E streets, SE.					49.0	.006	.002	.0010	18.0				

TABLE 12.—*Results of analyses of the waters of shallow wells in the District of Columbia, southwest section.*

No.	Location.	Date of analysis.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
		1906.				
104	South Capitol and M streets	Aug. 8	Slight	Woody	Considerable	Very slight, pieces of wood.
104	Ford's brickyard	Sept. 19				

No.	Location.	Total residue.	Mineral matter.	Volatile matter.	Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of saturation.	Oxygen consumed.
							Free.	Albuminoid.						
												° *C.*		
104	South Capitol and M streets	448	320	28	No charring, odor of hydrochloric acid, slightly disagreeable.	97.5	0.032	0.028	0.0125	40.0	7.00	16.5	71.86	1.3
104	Ford's brickyard					72.5				17.5				

TABLE 13.—*Number and location of shallow wells which from chemical analyses show (1) immediate sewage pollution; (2) remote pollution, and (3) no pollution.*

IMMEDIATE SEWAGE POLLUTION.

No. of well.	Location.	No. of well.	Location.
	Northeast.		*Southeast*—Continued.
24	Fourth and E streets.	35	Third and C streets.
38	E street between Eighth and Ninth streets.	91	Harrison avenue and Seventeenth street.
40	Eighth and A streets.	101	Third street and Pennsylvania avenue.
217	Benning crossroads.	116	Jefferson street, between Monroe and Fillmore streets.
218	Benning School.	139	L street, between Thirteenth and Fourteenth streets.
225	South Dakota and Vista street.	145	Eleventh street and South Carolina avenue.
	Northwest.	183	Hamilton road.
8	Tenth and N streets.	185	Stanton and Pomeroy streets.
13	Third street and Indiana avenue.	208	Good Hope School.
72	Third and L streets.	209	Twentieth and Joliet streets.
202	Pump, Zoological Park.	385	T street, Hillsdale.
204	Massachusetts avenue near Wisconsin avenue.	422	Ninth and E streets.
235	Hurst and Elliott streets.		*Southwest.*
	Southeast.	104	South Capitol and M streets.
30	Fourth street and South Carolina avenue.		

REMOTE POLLUTION.

No. of well.	Location.	No. of well.	Location.
	Northeast.		*Northwest*—Continued.
23	Third and D streets.	57	Thirty-fourth street and Volta place.
26	Second and G streets.	58	Thirty-fourth street and Wisconsin avenue.
28	Sixth street and Maryland avenue.	67	Thirty-fifth and Reservoir streets.
109	North Capitol, between B and C streets.	77	Sixteenth and Corcoran streets.
129	Keating street, between Lincoln avenue and First street.	111	New Jersey avenue and Pierce street.
135	Eleventh and F streets.	128	Eighth street and Barry place.
	Northwest.	131	New Jersey avenue and Morgan street.
5	Sixth street, between F and G streets.	169	Newton street east of Brightwood avenue.
6	Ninth and H streets.	170	Sixth street north of Fairmont street.
9	Tenth and K streets.		*Southeast.*
11	Seventeenth and K streets.	32	Fifth and G streets.
14	New York avenue, between Fourth and Fifth streets.	34	Fourth and C streets.
15	Massachusetts avenue, between Sixth and Seventh streets.	92	Seventh and B streets.
44	Wisconsin avenue and Q street.	102	Seventh, between B and C streets.
45	Thirty-second and Q streets.	103	Eighth and D streets.
46	Wisconsin avenue and P street.	117	Jackson and Fillmore streets.
48	Twenty-eighth and O streets.	146	I street, between Eleventh and Twelfth streets.

UNPOLLUTED.

No. of well.	Location.	No. of well.	Location.
	Northeast.		*Northwest*—Continued.
224	Quincy street (old Philadelphia).	130	North Capitol and Randolph streets.
	Northwest.	175	Thirty-third street and Wisconsin avenue.
127	Twelfth street and Florida avenue.	226	Brightwood avenue (near District line).

TABLE 14.—*Number and location of shallow wells according to the bacteriological examination showing (1) sewage pollution; (2) fair, and (3) good.*

SEWAGE POLLUTION OR SURFACE CONTAMINATION.

No. of well.	Location.	No. of well.	Location.
	Northeast.		*Northwest*—Continued.
24	Fourth and E streets.	175	Thirty-third street and Wisconsin avenue.
38	E street, between Eighth and Ninth streets.	202	Pump, Zoological Park.
135	Eleventh and F streets.	226	Brightwood avenue.
217	Benning crossroads.	235	Hurst and Elliott streets.
218	Benning School.		*Southeast.*
225	South Dakota avenue and Vista street.	30	Fourth street and South Carolina avenue.
	Northwest.	32	Fifth and G streets.
8	Tenth and N streets.	35	Third and C streets.
9	Tenth and K streets.	91	Harrison avenue and Seventeenth street.
13	Third street and Indiana avenue.	101	Third street and Pennsylvania avenue.
15	Massachusetts avenue, between Sixth and Seventh streets.	139	L street, between Thirteenth and Fourteenth streets.
46	Wisconsin avenue and P street.	145	Eleventh street and South Carolina avenue.
48	Twenty-eighth and O streets.	183	Hamilton road.
77	Sixteenth and Corcoran streets.	209	Twentieth and Joliet streets.
111	New Jersey avenue and Pierce streets.	422	Ninth and E streets.
128	Eighth street and Barry place.		*Southwest.*
131	New Jersey avenue and Morgan street.		
169	Newton street east of Brightwood avenue.	104	South Capitol and M streets.

FAIR.

No. of well.	Location.	No. of well.	Location.
	Northeast.		*Northwest*—Continued.
23	Third and D streets.	45	Thirty-second and Q streets.
26	Second and G streets.	57	Thirty-fourth street and Volta place.
28	Sixth street and Maryland avenue.	130	North Capitol and Randolph streets.
40	Eighth and A streets.	204	Massachusetts avenue near Wisconsin avenue.
109	North Capitol, between B and C streets.		*Southeast.*
224	Quincy street (old Philadelphia).	103	Eighth and D streets.
	Northwest.	146	I street, between Eleventh and Twelfth streets.
11	Seventeenth and K streets.	208	Good Hope School.
14	New York avenue, between Fourth and Fifth streets.	385	T Street hill, Hillsdale.

GOOD.

No. of well.	Location.	No. of well.	Location.
	Northeast.		*Northwest*—Continued.
129	Keating street, between Lincoln avenue and First street.	170	Sixth street north of Fairmont street.
	Northwest.		*Southeast.*
5	Sixth street, between F and G streets.	34	Fourth and C streets.
6	Ninth and H streets.	92	Seventh and B streets.
44	Wisconsin avenue and Q street.	102	Seventh street, between B and C streets.
58	Thirty-fourth street and Wisconsin avenue.	116	Jefferson street, between Monroe and Fillmore streets.
67	Thirty-fifth and Reservoir streets.	117	Jackson and Fillmore streets.
72	Third and L streets.	185	Stanton and Pomeroy streets.
127	Twelfth street and Florida avenue.		

TABLE 15.—*List of wells which on account of chemical and bacteriological findings and general insanitary surroundings are regarded as unfit for drinking purposes.*

No. of well.	Location.	No. of well.	Location.
	Northeast.		*Northwest*—Continued.
24	Fourth and E streets.	128	Eighth street and Barry place.
38	E street, between Eighth and Ninth streets.	131	New Jersey avenue and Morgan street.
135	Eleventh and F streets.	169	Newton street east of Brightwood avenue.
217	Bennings crossroads.	175	Thirty-third street and Wisconsin avenue.
218	Bennings School.	202	Pump, Zoological Park.
225	South Dakota avenue and Vista street.		*Southeast.*
	Northwest.	30	Fourth street and South Carolina avenue.
8	Tenth and N streets.	32	Fifth and G streets.
9	Tenth and K streets.	35	Third and C streets.
13	Third street and Indiana avenue.	91	Harrison avenue and Seventeenth street.
15	Massachusetts avenue, between Sixth and Seventh streets.	101	Third street and Pennsylvania avenue.
46	Wisconsin avenue and P street.	116	Jefferson street between Monroe and Fillmore streets.
48	Twenty-eighth and O streets.		*Southwest.*
77	Sixteenth and Corcoran streets.	104	South Capitol and M streets.
111	New Jersey avenue and Pierce street.		

TABLE 16.—*Summary of 14 analyses of the waters of the reservoirs and storage basin, made at intervals of 3–4 days to 1 week apart from July 30 to September 27, 1906.*

Reservoir.	Turbidity.[a]	Total solids.			Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.		Free.	Albuminoid.					
Dalecarlia, inlet	221	203	156	47.1	2.6	0.024	0.161	0.0031	0.61	7.44	89.6	4.1
Dalecarlia, outlet	99.0	163	115	48	2.61	.027	.131	.0051	.57	7.62	92.4	3.4
Georgetown	55.2	160	111	49	2.61	.022	.117	.0065	.60	7.44	90.0	3.3
Washington City (unfiltered)	46.3	141	100	41	2.47	.017	.096	.0056	.61	7.60	90.0	3.0
Storage basin (filtered)	4.6	127	88	39	2.53	.015	.054	.0003	.67	5.87	71.4	2.0

[a] Average of all readings made.

TABLE 17.—*Summary of the results of analyses made in the laboratory of the filtration plant of weekly samples of the waters of the reservoirs from February 13, 1906, to June 26, 1906.*

[Compiled from Captain Cosby's annual report.]

Reservoir.	Suspended solids.	Turbidity.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.
				Free.	Albuminoid.			
Dalecarlia, inlet	180	223	2.0	0.032	0.244	0.0033	0.79	....
Dalecarlia, outlet	56	96	1.7	.029	.152	.0028	.78	....
Georgetown	34	53	1.7	.016	.124	.0033	.77	....
Washington City	....	31	1.6	.015	.073	.0028	.79	9.72
Storage basin (filtered)	....	4	1.6	.010	.041	.0004	.92	8.10

TABLE 18.—*Physical and chemical improvement in the water of the Potomac accomplished by storage and sedimentation.*

[Compiled from analyses made in the division of chemistry of the Hygienic Laboratory, covering a period of 11 weeks, from July 16 to September 28, 1906.]

Reservoir.	Turbidity.	Total solids.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
				Free.	Albuminoid.					
Dalecarlia, inlet	221	203.0	2.6	0.024	0.161	0.0031	0.61	7.44	89.6	4.1
Washington City	46	141.0	2.47	.017	.096	.0056	.61	7.60	90.4	3.0
Improvement in parts per million	175	62.0	.13	.007	.065	......	......	......	......	1.1
Improvement in per cent	79	30.5	5.0	29.0	40.3	......	......	......	......	27.0

TABLE 19.—*Physical and chemical improvement in the water of the Potomac accomplished by storage and sedimentation.*

[Compiled from analyses made in the laboratory of the filtration plant, covering a period of 20 weeks, from February 13 to June 26, 1906.]

Reservoir.	Turbidity.	Suspended solids.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen	Per cent of saturation.
				Free.	Albuminoid.				
Dalecarlia, inlet	223.0	180	2.0	0.032	0.244	0.0033	0.79	......	......
Washington City	31.0	......	1.6	.015	.073	.0028	.79	9.72	94.4
Improvement in parts per million	192.0	......	.4	.017	.171	.0005	......	......	......
Improvement in per cent	86.1	......	20.0	53.1	70.0	15.0	......	......	......

TABLE 20.—*Chemical improvement of Potomac water as the result of filtration.*

Compiled from analyses made in the division of chemistry of the Hygienic Laboratory, covering a period of 11 weeks, from July 16 to September 28, 1906.]

Reservoir.	Turbidity.	Total solids.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
				Free.	Albuminoid.					
Washington City	46.3	141.0	2.47	0.017	0.096	0.0056	0.61	7.60	90.0	3.0
Storage basin	4.6	127.0	2.53	.015	.054	.0003	.67	5.87	71.4	2.0
Improvement in parts per million	41.7	14.0	......	.002	.042	.0053	......	......	......	1.0
Improvement in per cent	90.0	9.9	......	11.8	43.7	94.6	......	......	......	33.3

TABLE 21.—*Chemical improvement of Potomac water as the result of filtration.*

[Compiled from analyses made in the laboratory of the filtration plant, covering a period of 20 weeks, from February 13 to June 26, 1906, and given in annual report of Captain Cosby, Corps of Engineers.]

Reservoir.	Turbidity.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.
			Free.	Albuminoid.				
Washington City	31.0	1.6	0.015	0.073	0.0028	0.79	9.72	94.4
Storage basin	4.0	1.6	.010	.041	.0004	.92	8.10	78.2
Improvement in parts per million	27.0	....	.005	.032	.0024	....	....	....
Improvement in per cent	87.1	....	33.3	43.8	85.7	....	....	....

TABLE 22.—*Chemical improvement of Potomac water as the result of subsidence and filtration.*

[Compiled from analyses made in the division of chemistry of the Hygienic Laboratory, covering a period of 11 weeks, from July 16 to September 28, 1906.]

Reservoir.	Turbidity.[a]	Total solids.			Chlorine.	Ammonia.		Nitrites.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
		Total residue.	Mineral matter.	Volatile matter.		Free.	Albuminoid.				
Dalecarlia, inlet	221.0	203.0	156	47.1	2.6	0.024	0.161	0.0031	7.44	89.6	4.1
Storage basin	4.6	127.0	88	39	2.53	.015	.054	.0003	5.87	71.4	2.0
Improvement in parts per million	216.4	76.0	63	8.1	.07	.009	.107	.0028	......	......	2.1
Improvement in per cent	97.9	37.4	43.6	17.1	2.7	37.5	66.0	90.0	......	......	51.0

[a] Average of all readings made.

Dissolved oxygen consumed in oxidation, 21 per cent.

TABLE 23.—*Chemical improvement of Potomac water as the result of subsidence and filtration.*

Compiled from analyses made in the laboratory of the filtration plant, covering a period of 20 weeks, from February 13, 1906, to June 26, 1906, and given in annual report of Captain Cosby, Corps of Engineers.]

Reservoir.	Turbidity.	Chlorine.	Ammonia.		Nitrites.	Dissolved oxygen.	Per cent of saturation.
			Free.	Albuminoid.			
Dalecarlia, inlet	223.0	2.0	0.032	0.244	0.0033	....	([a])
Washington City reservoir	....	....	....	....	....	9.72	94.4
Storage basin, filtered	4.0	1.6	.010	.041	.0004	8.10	78.2
Improvement in parts per million	219.0	0.4	.022	.203	.0029	....	....
Improvement in per cent	98.7	20.0	69.0	83.0	87.9	....	....

Dissolved oxygen consumed in oxidation, 16.7 per cent.

[a] According to analyses given in Captain Cosby's report the dissolved oxygen was determined only in the Washington City reservoir and in the filtered water of the storage basin. It may be observed, however, in this connection that the amount of dissolved oxygen suffers but little change in passing through the several reservoirs until the water passes through the sand filters, when it is reduced from 16.7 to 21 per cent.

TABLE 24.—*Composition of tap water as compared with the water of Dalecarlia reservoir inlet and the water of the storage basin.*

Water.	Total residue.	Mineral matter.	Volatile matter.	Chlorine.	Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
Dalecarlia reservoir, inlet [a]	203	156	47.1	2.6	0.024	0.161	0.0031	0.61	7.44	89.6	4.1
Storage basin, filtered [b]	127	88	39	2.53	.015	.054	.0003	.67	5.87	71.4	2.0
Tap or hydrant [c]	123	75	48	2.69	.011	.031	.00007	.63	6.20	81.39	1.83

[a] Average of 14 analyses covering a period of 9 weeks from July 31 to Sept. 27, 1906.
[b] Average of 14 analyses covering a period of 9 weeks from July 31 to Sept. 27, 1906.
[c] Average of 49 analyses covering a period of 11 weeks from July 16 to Sept. 28, 1906.

TABLE 25.—*Averages of chemical analyses of tap water for different periods during July, August, and September of 1906.*

Period covered by the examination.	Total solids. Total.	Total solids. Mineral matter.	Total solids. Volatile matter.	Chlorine.	Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	Dissolved oxygen.	Per cent of saturation.	Oxygen consumed.
July 16 to 20, inclusive (average of 11 analyses)	123.1	73.7	49.4	2.41	0.0136	0.0371	0.00015	0.62	7.06	86.77	2.15
July 23 to 27, inclusive (average of 15 analyses)	126.3	68.4	57.9	2.54	.010	.0389	.00004	.664	6.36	78.00	2.24
July 31 to Aug. 6, inclusive (average of 18 analyses)	117.4	75.8	41.6	2.97	.0136	.023	.00006	.596	5.80	71.61	1.57
Sept. 28, (average of 5 analyses)	132.4	92.6	39.8	2.74	.001	.0185	Trace.	.68	......	....	.80
July 16 to Sept. 28, inclusive (average of 49 analyses)	122.9	74.9	48	2.69	.0111	.0308	.00007	.63	6.2	81.39	1.83

TABLE 26.—*Comparison of analyses of tap water for summer period of 1904* [a] *and 1906.*

[Compiled from data given in "The Potomac River Basin," Water-Supply Paper No. 192, United States Geological Survey, by Horatio M. Parker, 1904, and analyses made in the Hygienic Laboratory, division of chemistry.]

Source of data.	Period.	Total solids. Total residue.	Total solids. Mineral matter.	Total solids. Volatile matter.	Chlorine.	Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	Required oxygen.
Data contained in bulletin of Geological Survey (average of 10 analyses).	June 3–Sept. 28, 1904.	184	144	40	4.6	0.037	0.28	0.0026	0.39	1.79
Hygienic Laboratory, division of chemistry (average of 49 analyses).	July 16–Sept. 28, 1906.	123	75	48	2.69	.011	.031	.00007	.63	1.83

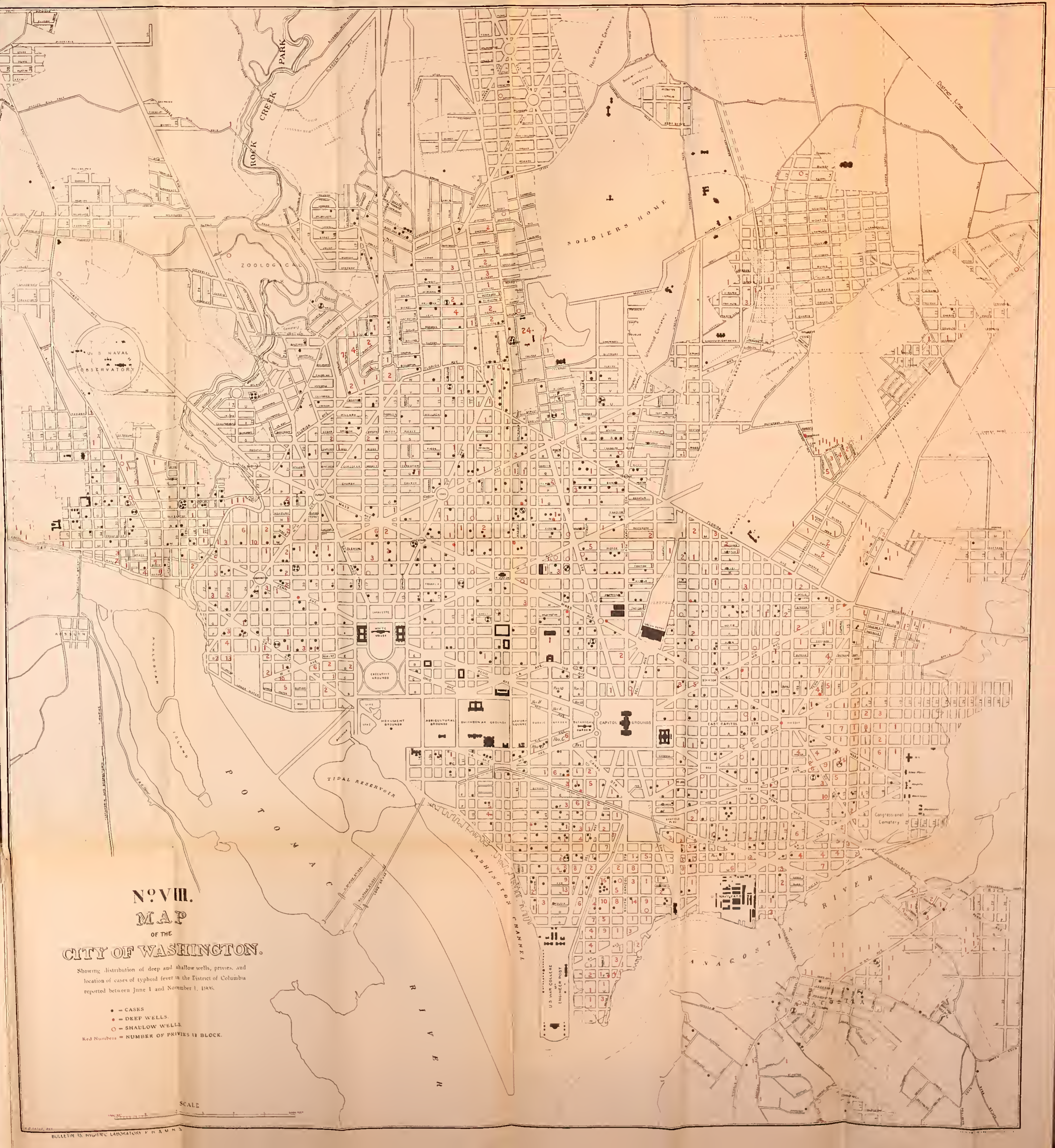
[a] Before the filter plant went into operation.

TABLE 27.—*Results of analyses of miscellaneous water supplies: (1) Government Hospital for the Insane, (2) Soldiers' Home, and (3) Chevy Chase.*

No.	Location.	Date.	General characteristics.			
			Color.	Odor.	Turbidity.	Sediment.
	Government Hospital for the Insane:	1906.				
88	Well	Aug. 6	Nearly colorless (8)	None	Slight (8)	None.
89	Storage cistern	do	Distinctly yellow (11)	do	Slight (12)	Do.
112	Well	Aug. 10	(4)	Slight, sulphurous	(8)	Slight, coarse yellowish brown.
113	Storage cistern	do	(3)	None	(13)	Slight, brown, fine particles.
114	Tap in engine room	do	(3)	do	(16)	None.
115	Tap, administration building	do	(2)	do	(8)	Do.
343	Soldiers' Home	Sept. 28	None	do	None	Do.
	Chevy Chase:					
158	Well	Aug. 21	do	do	do	Do.
159	Spring	do	do	do	do	Do.
214	Tap, general water supply, one square east of post-office.	Aug. 30	Very slight (2)	do	Very slight (3)	Do.
		Oct. 23	None	do	None	Do.
215	Chevy Chase school	do	Slightly yellowish	do	(18)	Do.

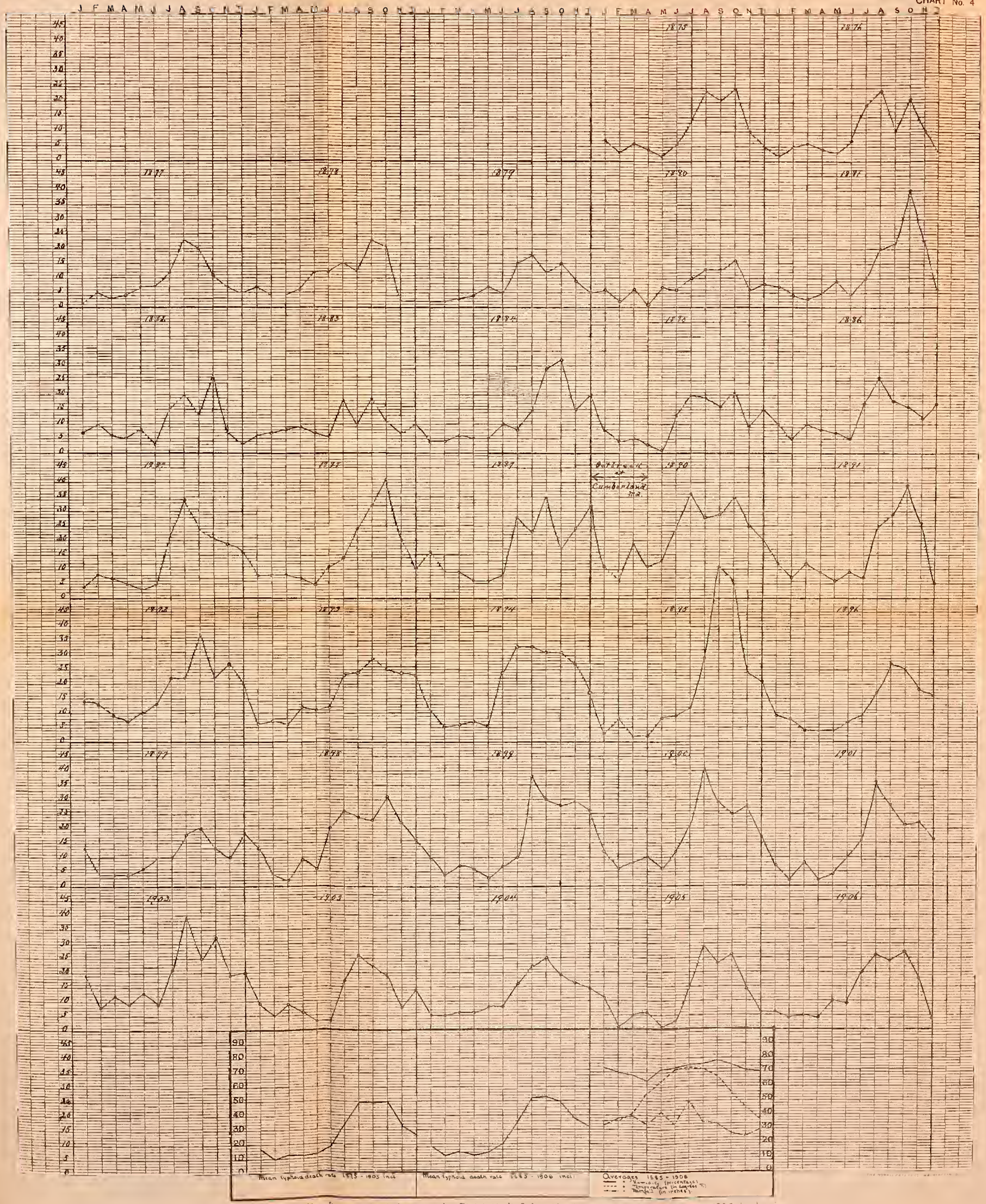
No.	Location.	Total solids.			Conduct on ignition.	Chlorine.	Ammonia.		Nitrites.	Nitrates.	Dissolved oxygen.	Temperature.	Per cent of of saturation.	Oxygen required
		Total residue.	Mineral matter.	Volatile matter.			Free.	Albuminoid.						
	Government Hospital for the Insane:											° C.		
88	Well	111	71	40	No charring, no odor	10.4	0.052	0.003	0.0003	0.01	10.65	18.5	111.5	0.10
89	Storage cistern	97	67	30	No charring, slight odor	8.4	.062	.016	.00075	......	10.69	20.0	116.3	.15
112	Well	149	99	50	No charring, no odor	9.5	.055	.008	0	.01	12.0	18.5	126.8	.05
113	Storage cistern	140	90	50	No charring, odor slightly disagreeable.	8.6	.053	.000	0	.01	11.4	19.5	122.9	.25
114	Tap in engine room	166	111	55	do	8.5	.040	.000	.0005	.02	9.43	19.5	101.6	.25
115	Tap, administration building	145	112	33	do	8.3	.018	.000	.0005	.05	8.21	24.0	96.5	.35
343	Soldiers' Home	81	42	39	Very slight charring, very slight disagreeable odor.	4.95	.000	.006	.0001	5.0	......	14.5	......	......
	Chevy Chase:													
158	Well	136	108	28	No charring, slightly disagreeable odor.	18.5	.017	.006	.0045	3.6	9.84	14.4	95.80	.05
159	Spring	51	29	22	No charring, no odor	2.1	.002	.000	0	2.0	9.43	14.4	91.82	.30
214	Tap, general water supply, one square east of post-office.	122	98	24	do	4.6	.000	.056	0	1.0	9.25	22.0	104.63	1.4
		96	70	26	do	4.8	.028	.004	0	1.0	......	......	......	......
215	Chevy Chase school	134	86	48	......	8.1	.048	.004	Trace.	.40	......	......	......	......

No. VII.
MAP
OF THE
CITY OF WASHINGTON.
Showing the location of cases of typhoid fever reported June 1 to November 1, 1906, according to date of onset
May 1 to 15 inclusive
May 16 to 31 inclusive
June 1 to 15 inclusive
June 16 to 30 inclusive.
July 1 to 15, inclusive
July 16 to 31 inclusive
August 1 to 15 inclusive
August 16 to 31 inclusive
September 1 to 15 inclusive
September 16 to 30 inclusive
October 1 to 15, inclusive
October 16 to 31, inclusive
SCALE
ROCK CREEK PARK
ZOOLOGICAL PARK
SOLDIERS HOME
U.S. NAVAL OBSERVATORY
District Line
WHITE HOUSE
EXECUTIVE GROUNDS
MONUMENT GROUNDS
AGRICULTURAL GROUNDS
SMITHSONIAN GROUNDS
CAPITOL GROUNDS
TIDAL RESERVOIR
WASHINGTON CHANNEL
U.S. NAVY YARD
U.S. WAR COLLEGE AND ENGINEER POST
POTOMAC RIVER
ANACOSTIA RIVER
ANALOSTAN ISLAND
Congressional Cemetery



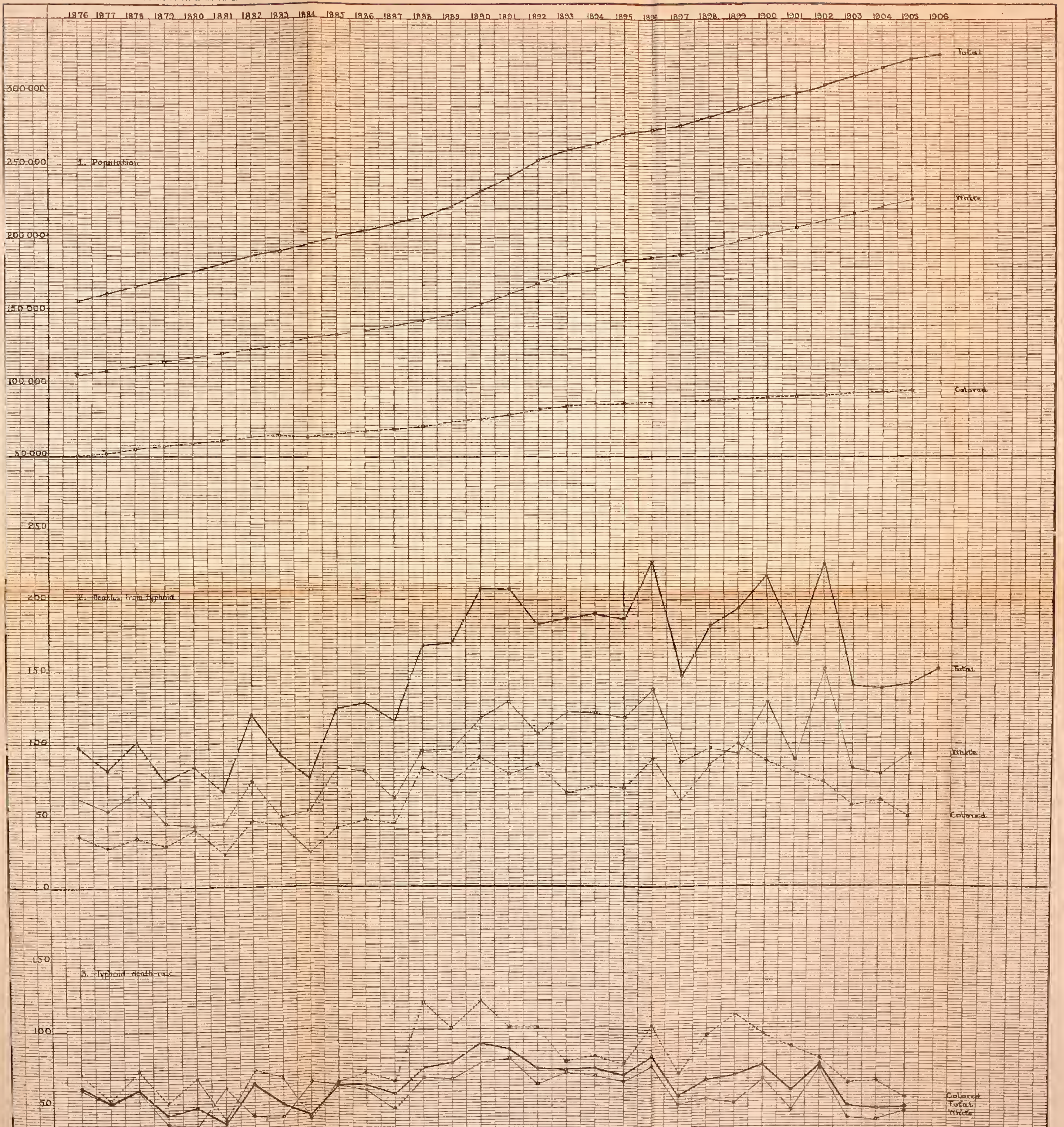
No. VIII.
MAP
OF THE
CITY OF WASHINGTON.
Showing distribution of deep and shallow wells, privies, and location of cases of typhoid fever in the District of Columbia reported between June 1 and November 1, 1906
• = CASES
• = DEEP WELLS.
○ = SHALLOW WELLS.
Red Numbers = NUMBER OF PRIVIES IN BLOCK.
SCALE
ROCK CREEK PARK
SOLDIERS HOME
ZOOLOGICAL
U.S. NAVAL OBSERVATORY
Rock Creek Cemetery
Glenwood Cemetery
District Line
WHITE HOUSE
EXECUTIVE GROUNDS
MONUMENT GROUNDS
AGRICULTURAL GROUNDS
SMITHSONIAN GROUNDS
CAPITOL GROUNDS
BOTANICAL GARDEN
UNION STATION
TIDAL RESERVOIR
POTOMAC RIVER
WASHINGTON CHANNEL
ANACOSTIA RIVER
ANALOSTAN ISLAND
U.S. WAR COLLEGE
Congressional Cemetery
EAST CAPITOL
BULLETIN 35, HYGIENIC LABORATORY

CHART No. 4

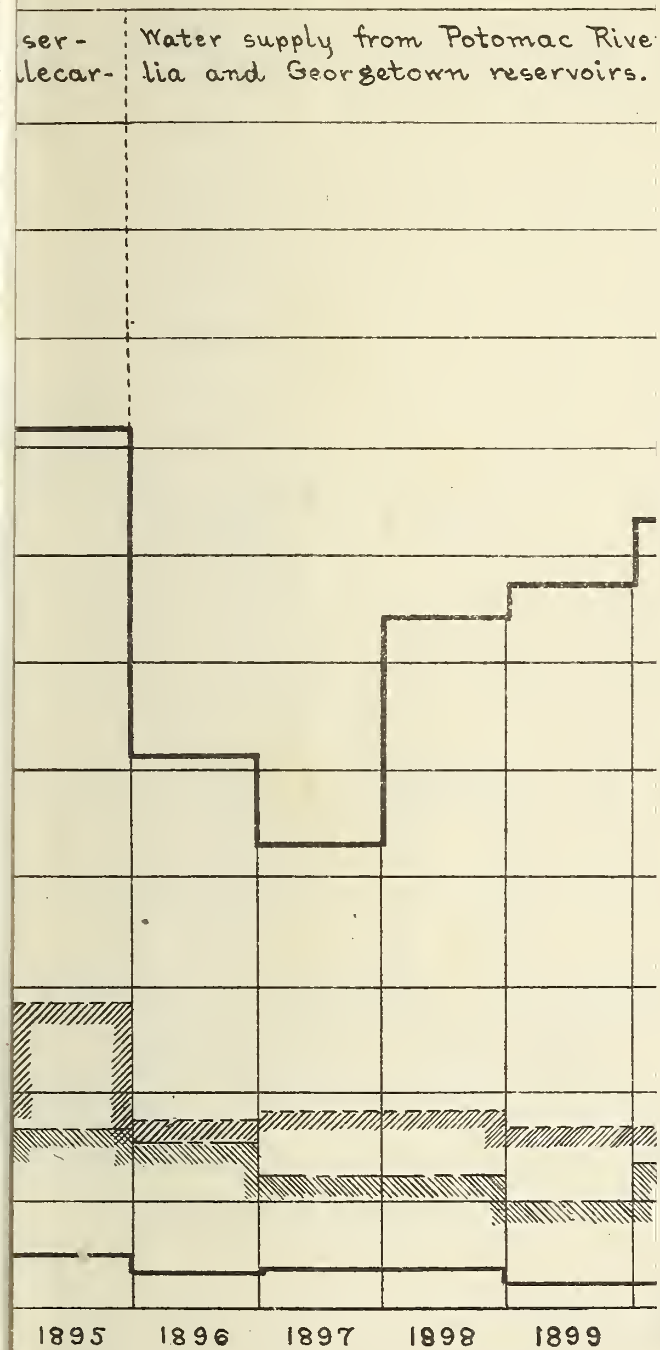


Curve showing deaths from typhoid fever in the District of Columbia, by months from 1875 to 1906 inclusive

BULLETIN 35, HYGIENIC LABORATORY, P. H. & M. H. S.

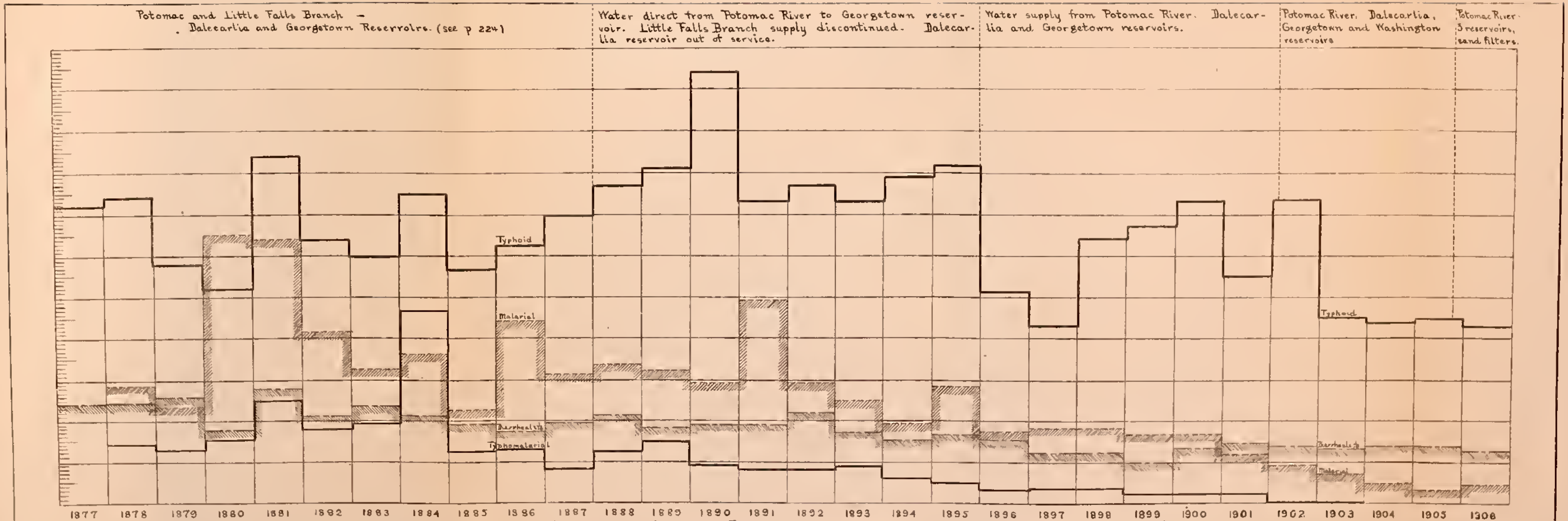


1. Population of the District of Columbia, by years, from 1876 to 1906.
2. Deaths from typhoid fever in the District of Columbia, 1876 to 1906.
3. Deaths per 100 000 from typhoid fever in the District of Columbia, 1876 to 1906.

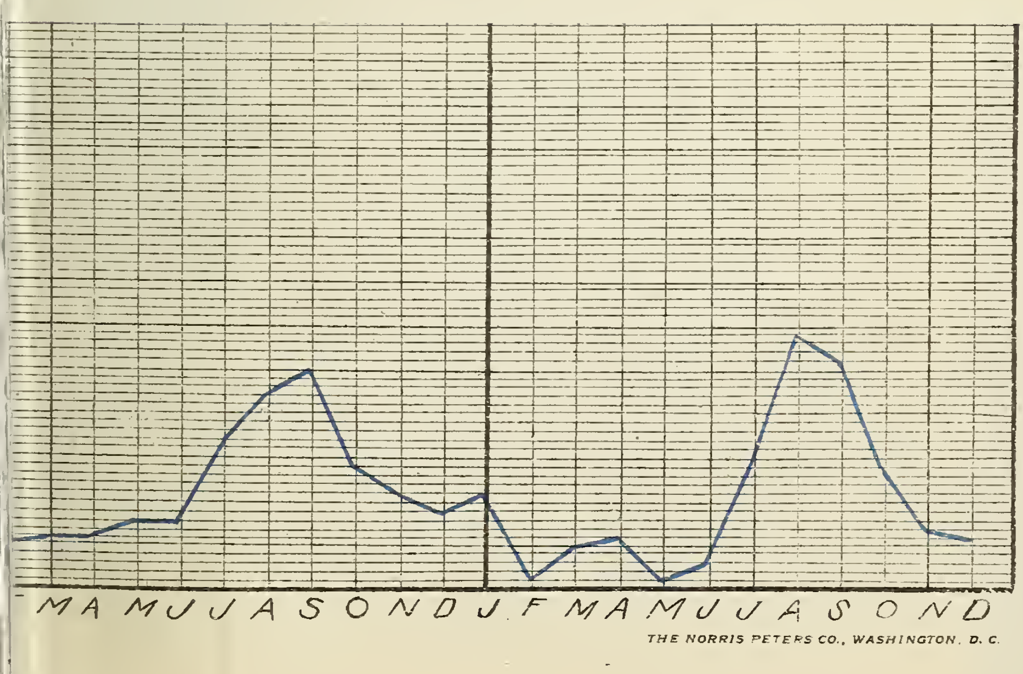


and Typho-malaria in the District of

CHART No. 6

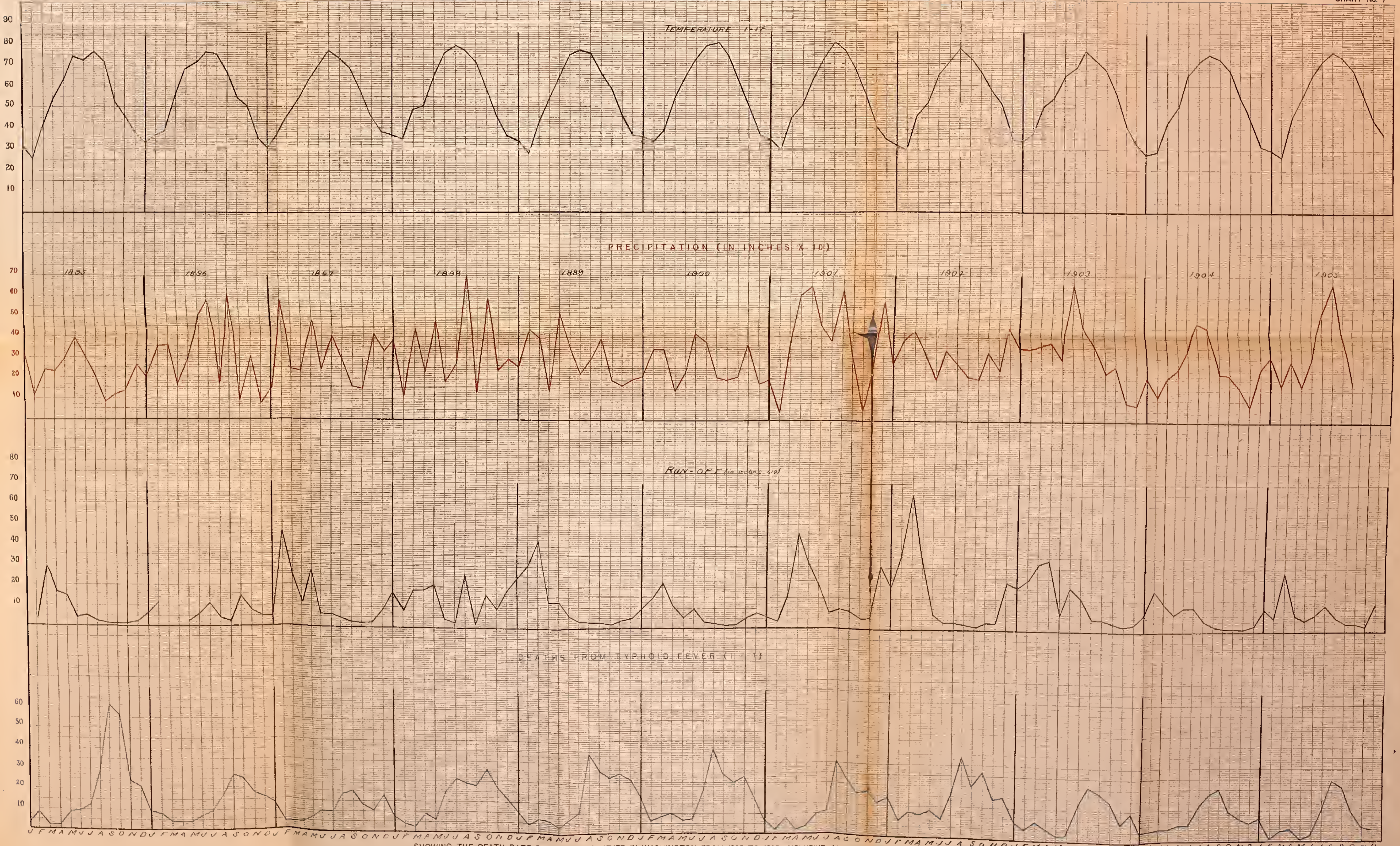


Curve showing deaths per 100 000 per year from Typhoid Fever, Malaria, Diarrheal diseases and Typho-malaria in the District of Columbia from 1877 to 1906 inclusive



THE NORRIS PETERS CO., WASHINGTON, D. C.

CHART No. 7



SHOWING THE DEATH RATE FROM TYPHOID FEVER IN WASHINGTON FROM 1895 TO 1905, INCLUSIVE ALSO THE RUN-OFF, PRECIPITATION AND TEMPERATURE FOR CORRESPONDING YEARS